

Vol. 6.

MARCH, 1919

No. 3.

JOURNAL
OF THE
BOSTON SOCIETY
OF
CIVIL ENGINEERS



Published monthly, excepting July and August, by the Society,
715 Tremont Temple, Boston, Massachusetts.

Entered as second-class matter, January 15, 1914, at the Post Office at Boston, Mass.,
under Act of August 24, 1912.

Acceptance for mailing at special rate of postage provided for in Section 1103, Act of
October 3, 1917; authorized on July 16, 1918.

Subscription Price, \$4.00 a year (Ten Numbers)
50 Cents a Copy

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BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PROCEEDINGS

PAPERS IN THIS NUMBER.

"THE BOSTON ARMY SUPPLY BASE."

"General Features of Project." Frederic H. Fay.

"Construction Features." Charles R. Gow.

"From the Contractor's Standpoint." Wm. H. Kearns.

"General Data." Charles M. Spofford.

CURRENT DISCUSSION.

Paper.	Author.	Published.	Discussion Closes.
"The Operation of the Utilities at Camp Devens, Mass."	E. W. Briggs.	Feb.	Apr. 10.

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Contributors are hereby notified that proof will not be submitted to them for examination unless requested before the 10th of the month preceding the month of publication.

MINUTES OF THE MEETING.

BOSTON, February 19, 1919. — A regular meeting of the Boston Society of Civil Engineers was held this evening in Chipman Hall, Tremont Temple, and was called to order at 7.50 o'clock by the President, Charles M. Spofford.

There were present 205 members and visitors, including ladies.

The record of the January meeting was read and approved.

The President reported for the Board of Government the election to membership in the grade of Member of Messrs. Raymond H. A. Carter, James Andreas Christenson, Linton Hart and Thomas Bartholomew Kenney.

The President also reported for the Board of Government that it had considered the matter referred to it by the Society at the last meeting, in relation to the recognition in special manner of the members who were responsible for the resuscitation of the Society in 1874, and that the Board recommended the passage of the following:

Voted: That those members who took part in reviving the Society in 1874 be exempted from further payment of dues, and that their names be listed separately in the membership list.

By a unanimous vote the recommendation was adopted. The names of the members to whom this vote will apply are Desmond FitzGerald, Frank L. Fuller, Clemens Herschel, Edward W. Howe, Wilbur F. Learned, Henry Manley, George S. Rice and Francis C. Tucker.

The President announced the deaths of the following members of the Society, and by vote the President was requested to appoint committees to prepare memoirs:

James Hayes, Jr., who died September 26, 1918.

Fred E. Sauer, Jr., who died January 20, 1919.

Gilbert Hodges, who died February 13, 1919.

John S. Humphrey, who died February 15, 1919.

Mr. Desmond FitzGerald, for the committees appointed to prepare memoirs of Past President Frederick Brooks and Mr. Thomas Aspinwall, read the memoirs which had been prepared, and they were accepted and ordered printed in the JOURNAL.

Mr. Isaac W. Litchfield, chief of the Professional Section, U. S. Employment Service, Department of Labor, was then introduced and spoke of the work already done by the New England Employment Service and what it hopes to do in the future.

The President then called on Past President George F. Swain, who spoke of "The Engineering Conditions and Problems in France." Professor Swain was one of the delegation of American engineers sent to France in response to an invitation from the French Congress of Civil Engineers, to confer with members of that Congress on matters of reconstruction, particularly along civil engineering lines. Professor Swain, with the aid of lantern slides, gave a most interesting and graphic account of the conditions which he found in France, and spoke of the work done by the delegation of American engineers and what he hoped would be accomplished by the appointment of a permanent Franco-American International Engineering Committee.

A short discussion followed, in which President Spofford, Mr. FitzGerald, Mr. Stearns and others took part.

Adjourned.

S. E. TINKHAM, *Secretary.*

APPLICATIONS FOR MEMBERSHIP.

[March 15, 1919.]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

FALKENBERG, JOHN JOSEPH, Boston, Mass. (Age 20, b. Caldwell, Kans.) Received degree of B.S. at Mass. Inst. of Technology with Class of 1919, civil engineering course. Refers to J. B. Babcock, 3d, C. B. Breed, Dwight Porter, A. G. Robbins, G. E. Russell and C. M. Spofford.

GAGE, ELLIOT HOWES, South Weymouth, Mass. (Age 27, b. Brooklyn, N. Y.) Graduate of Mass. Inst. of Technology, 1913, sanitary engineering course. From June, 1913, to May, 1915, assistant in Engrg. Div., Mass. State Dept. of Health; from May, 1915, to April, 1916, member American Red Cross Sanitary Comm. to Serbia; from June to December, 1916, assistant engineer on water works and sewer construction at Lyons, N. Y.; from January to May, 1917, draftsman with Burgess Co., Airplanes, Marblehead, Mass.; from May, 1917, to January, 1919, in military service, covering three months in training camp, 14 months as 2d Lieut., Engrs., U.S.R., and three months as 1st Lieut., Engrs., U.S.A.; from February, 1919, to date, assistant in Engrg. Div., Mass. State Dept. of Health. Refers to Bertram Brewer, X. H. Goodnough, H. E. Holmes, Dwight Porter and C. M. Spofford.

JACKSON, RALPH TEMPLE, Boston, Mass. (Age 39, b. Great Pond, Me.) Graduate of Mass. Inst. of Technology, 1906, degree of B.S. in Architecture; received degree of M.S., 1907. From 1907 to 1909, superintended construction of New Union Hospital, Fall River, Mass. — steel and concrete construction; maintained office in Fall River from 1909 to 1915, and in Boston from 1915 to 1917, carrying out as architect and engineer approximately \$2,000,000 worth of work, mainly reinforced concrete construction; from 1917 to July, 1918, employed as engineer by American Shipbuilding and Transportation Co. to lay out yard and mill, and by New England Ship and Barge Co. to design concrete on coal barge and cargo vessel; from July, 1918, to date, with Fay, Spofford & Thorndike on Boston Army Supply Base. Refers to B. A. Bowman, F. H. Fay, H. A. Gray, H. F. Sawtelle, C. M. Spofford and David Sutton.

REED, CARL BICKNELL, Norwood, Mass. (Age 26, b. South Weymouth, Mass.) Graduate of Worcester Polytechnic Inst., 1917, Sanitary Civil Dept. Until April, 1918, assistant state chemist, Concord, N. H.; from April, 1918, to date, with exception of two months in Sanitary Corps, U.S.A., chemist with Metcalf & Eddy. Refers to H. P. Eddy, A. L. Fales, A. W. French, A. L. Maddox and Leonard Metcalf.

WHITNEY, GORHAM HORATIO, West Medford, Mass. (Age 38, b. Roxbury, Mass.) Has been connected with Bay State Dredging & Contracting Co. for past twenty years, doing river and harbor improvement work; is now president and general superintendent of that company. Refers to H. S. Adams, C. R. Gow, F. W. Hodgdon, H. C. Robbins and J. W. Rollins.

ROLL OF HONOR.*

ADDITIONS.

- COFFIN, GROVER C. Private, Battery A, 119th Field Artillery, Am. Ex. Force, France.
 †COOMBS, ANTHONY A. Field Artillery Central Officers' School, Camp Taylor, Ky.
 †TANNATT, WILLARD C., Jr. Captain, Engineers, U.S.A.
 WHITING, MASON T. Captain, U. S. Service Club of America, DuPont Circle, Washington, D.C.

REVISIONS.

- CRAIGUE, JOSEPH S. Captain, Engineers, U.S.A., Chief Gas Officer, 2d Div., A. P. O. 710, Am. Ex. Force.
 RAND, ROBERT. Lieutenant, U. S. N. R. F., Asst. Force Communication Officer, U. S. Naval Headquarters, 30 Grosvenor Gardens, London, England.
 SAWYER, GEORGE S. 2d Lieutenant, Engrs., U. S. A., Adjutant Section Engr. Office, Base Section No. 6, A. P. O. 752, Am. Ex. Force, France.
 STROUT, HENRY E., Jr. Captain, Corps of Engrs., U. S. A., 319th Engrs., Am. Ex. Force.
 WIGGIN, THOMAS H. Major, Engrs., U. S. A., Am. Ex. Force, France.
 WORCESTER, ROBERT J. H. 1st Lieutenant, Co. E, 117th Engrs., Am. Ex. Force.

LIST OF MEMBERS.

ADDITIONS.

- CALDERARA, CHARLES A.....20 Prospect St., Rockland, Mass.
 CARTER, RAYMOND H. A.....34 India St., Boston, Mass.
 CHRISTENSON, JAMES A.....Southbridge, Mass.
 HART, LINTON.....80 Boylston St., Boston, Mass.

CHANGES OF ADDRESS.

- BARNEY, HAROLD B.....P. O. Box 292, Fall River, Mass.
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* Members who are in the service and have not yet reported that fact to the Secretary are earnestly requested to do so, stating branch of service, rank and military address.

† Has now been discharged from the service.

COGHLAN, JOHN H.	High Bridge, N. J.
COLBY, EDWIN W.	4815 Washington St., W. Roxbury, Mass.
EDDY, HARRISON P., Jr.	14 Beacon St., Boston, Mass.
FLAWS, JAMES B.	21 Elm St., No. Woburn, Mass.
FRENCH, CHARLES A.	Masonic Temple, Laconia, N. H.
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GARTLAND, EDWARD V.	Commonwealth Pier 5, Care Waterways and Public Lands Comm., Boston, Mass.
GUPPY, BENJAMIN W.	B. & M. R. R., North Station, Boston, Mass.
HARTWELL, DAVID A.,	Commissioner of Public Works and City Engr., Fitchburg, Mass.
HARWOOD, T. T. HUNTER	90 Main St., Rockport, Mass.
HORTON, FREEMAN H.	Care Coast and Geodetic Survey, Washington, D. C.
JOHNSON, FRANK W.,	Care Raymond Concrete Pile Co., 140 Cedar St., New York, N. Y.
KING, ARTHUR C.	228 Haddon Ave., Westmont, N. J.
PORTER, ARTHUR P.	Care New England Power Co., Worcester, Mass.
PUTNAM, CHARLES E.	33 Beacon St., Boston, Mass.
RESTALL, CHARLES H.,	Care F. F. Jonsberg Co., Old South Bldg., Boston, Mass.
RICHARDSON, EDWARD B.	7 Chatham St., Brookline, Mass.
ROBINSON, ASHLEY Q.	53 4th St., Attleboro, Mass.
SANBORN, FRANK B.	79 Sudbury St., Boston, Mass.
SEARS, CALVIN C.	3 Bryan Rd., Branford, Conn.
SKILLIN, FRED B.	43 Van Reipen Ave., Jersey City, N. J.
STONE, GEORGE C.	Altavista, Va.
WADSWORTH, GEORGE R.,	Care United Aircraft Engrg. Corp'n, 52 Vanderbilt Ave., New York, N. Y.
WILSON, ALBERT O.	135 Winsor Ave., Watertown, Mass.
YOUNG, ERVING M.	11 Warren St., Haverhill, Mass.

DEATHS.

HODGES, GILBERT	February 13, 1919
HUMPHREY, JOHN S.	February 6, 1919
SAUER, FRED E.	January 20, 1919

EMPLOYMENT BUREAU.

THE Board of Government has established an employment bureau for the Society, to be a medium for securing positions for its members and applicants for membership, and also for furnishing employees to members and others desiring men capable of filling responsible positions.

At the Society rooms two lists are kept on file, one of *positions available* and the other of *men available*, giving in each case detailed information in relation thereto.

MEN AVAILABLE.

445. Age 47. Graduate of Dartmouth College, degree of B.S. Experience covers five years with Massachusetts Metropolitan Water Board on reservoir construction and seventeen years in responsible charge of important municipal work; recently discharged from U. S. Army, where he held rank of captain, Q. M. C., Construction Division, having been assigned as officer in charge of utilities at U. S. A. general hospital. Would be interested in engineering position dealing with water, sewers, streets or operation and maintenance of utilities. Salary desired, \$3 000 per year.

446. Age 20. High-school graduate and student for four months at U. S. Naval Academy, Annapolis, Md. Has had experience as rodman with party laying out townships in Arizona desert, and as "sampler" on diamond drills for copper company. Desires position as rodman or chainman.

447. Age 36. Graduate of Brown University, 1903, civil engineering course, degree of S.B. Experience includes eight years as draftsman and instrumentman on preliminary investigations and design for sewer systems and sewage disposal, land drainage and road construction; has also had experience as draftsman in maintenance of way department of railroad and as mechanical draftsman with steam gage and valve company. Desires position as draftsman and surveyor. Salary desired, \$85 per month.

449. Age 21. Graduate of Mass. Inst. of Technology, civil engineering course, degree of B.S., having taken both hydraulic and railroad engineering options. Experience consists of one summer at surveying camp of Mass. Inst. of Technology and surveys in connection with Coast Artillery Officers' Training Camp, Fort Monroe, Va.

LIBRARY NOTES.

RECENT ADDITIONS TO THE LIBRARY.

U. S. Government Reports.

Annual Report of Director of Bureau of Mines for 1917-18.

Annual Report of Director of Geological Survey for 1917-18.

Book Lists compiled for United States Shipping Board on following subjects: Foreign Countries; Foreign Languages; Ships, Commerce and Merchant Marine; World Trade. (Miss) M. L. Prevost, comp.

Central Station Heating. John C. White.

Colloids and Flotation. Frederick G. Moses.

Contribution to Geology of Northeastern Texas and Southern Oklahoma. Lloyd William Stephenson.

Fuel Administration Engineering Bulletins as follows:
Boiler and Furnace Testing; Saving Coal in Steam Power Plants;
Boiler Water Treatment; Combustion and Flue Gas Analysis;
Burning Steam Sizes of Anthracite; Saving Steam in Industrial
Heating Systems.

Gold, Silver, Copper, Lead and Zinc in Eastern States
in 1917. James M. Hill.

Graphite in 1917. Henry G. Ferguson.

How to Improve the Hot-Air Furnace. Charles Whiting
Baker.

Innovations in Metallurgy of Lead. Dorsey A. Lyon and
Oliver C. Ralston.

Magnesium in 1917. Ralph W. Stone.

Melting Brass in Rocking Electric Furnace. H. W. Gillett
and A. E. Rhoads.

Methods of Shutting off Water in Oil and Gas Wells. F. B.
Tough.

Peat in 1917. C. C. Osbon.

Petroleum in 1916. John D. Northrop.

Description of Quantitative Classification of Igneous Rocks
with Tables for Calculation of Norm. Henry Stephens Wash-
ington.

Recreation Uses on National Forests. Frank A. Waugh.

Rock Quarrying for Cement Manufacture. Oliver Bowles.

Shorter Contributions to General Geology, 1917. David
White.

Talc and Soapstone in 1917. J. S. Diller.

Use of Hydrogen-Volatile-Matter Ratio in Obtaining Net
Heating Value of American Coals. A. C. Fieldner and W. A.
Selvig.

Water Systems for Farm Homes. George M. Warren.

Water-Supply Papers 410, 413.

When Coal-Oil Johnny Goes to Sea. Edward N. Hurley.

Why Our Ships Will Now Stay on the Ocean. Edward N.
Hurley.

State Reports.

New Hampshire. Report of Commission on Water Conservation and Water Power, 1917-18. Gift of C. H. Pierce.

Municipal Reports.

Hartford, Conn. Annual Report of Water Commissioners for 1917-18.

Providence R. I. Annual Report of Department of Public Works for 1918.

Miscellaneous.

American Highway Engineers' Handbook. Arthur H. Blanchard.

American Society of Mechanical Engineers: Transactions for 1917.

Railway Statistics of United States of America for 1917. Slason Thompson, ed.

Wharves and Piers. Carleton Greene.

LIBRARY COMMITTEE.

BOSTON SOCIETY OF CIVIL ENGINEERSFOUNDED 1848

PAPERS AND DISCUSSIONS

This Society is not responsible for any statement made or opinion expressed in its publications

**THE BOSTON ARMY SUPPLY BASE. — GENERAL
FEATURES OF PROJECT.**

By FREDERIC H. FAY,* MEMBER BOSTON SOCIETY OF CIVIL ENGINEERS.

(Presented December 18, 1918.)

OUR entry into the war brought to this country vast problems of production and transportation and the necessity for the coördination of our national resources, tasks which greatly overtaxed our then existing war machinery. For the solution of these problems the aid of the ablest civilians was sought and secured, to supplement the personnel of the government departments and bureaus. The country awoke to the fact that war had become a business and not merely a profession.

The Council of National Defense, a civilian organization, was set up in the spring of 1917, for the general study and planning of our war activities. Through committees of business and professional men who were specialists in their respective lines, the Council undertook to survey conditions in diverse fields of activity, all needed for the winning of the war, and to make recommendations for the coördination of these activities into a complex but complete and smoothly running war machine.

* Of Fay, Spofford & Thorndike, Consulting Engineers, 308 Boylston Street, Boston, Mass.

NOTE. — Discussion on this paper is invited, to be received by W. L. Butcher, Editor, 715 Tremont Temple, Boston, Mass., before May 10, 1919, for publication in a subsequent issue of the JOURNAL.

Among the many committees of the Council of National Defense was the committee on Terminal Port Facilities, under the able chairmanship of Francis Lee Stuart, a consulting engineer of New York, who had formerly been chief engineer of the Erie and later of the Baltimore and Ohio railroads. This committee was charged with the duty of studying the ports of the country, of making recommendations as to what ports should be selected for war work, and of making suggestions as to how the selected ports might best be utilized and developed to handle the vast amount of overseas shipments necessary for the transportation to and maintenance of our army in France. The work of the Committee on Terminal Port Facilities was essentially an engineering study of existing facilities at our principal ports, and the outlining, in a general way, of such additional facilities as might be found necessary; and the committee, as at first organized, included engineers prominent in port work of some of the larger ports of the country, other than Boston.

In July, 1917, consideration having been given to New York and certain other Atlantic ports, the attention of the committee was directed toward Boston, and as the speaker chanced to be in Washington at the time he was asked to attend a meeting of the committee and give some information as to conditions at this port. At this meeting of the committee a wire was sent to the Commission on Waterways and Public Lands of Massachusetts, requesting that a certain engineering representative of that Commission, who was most familiar with conditions at this port, be designated as a member of the Committee on Terminal Port Facilities — an assignment which, had it been granted, would not only have been most fortunate for the port of Boston, but equally helpful to the committee in its war work.

In the summer of 1917 there was a general feeling in Washington that it was useless to develop Boston as a war port owing to the hopelessness of the railroad situation in New England. Erroneously, the impression had gone abroad that our New England railroads were in such poor shape that they could not properly handle the business then passing through this port, and that further port business here was out of the question. It was most unfortunate for Boston and New England that this

false impression of our railroad situation was generally held throughout the rest of the country, and this doubtless accounted for some delay on the part of the Committee on Terminal Port Facilities in giving consideration to the port of Boston.

The summer of 1917 passed without any outward indication that, so far as this country's war activities were concerned, the port of Boston was even on the map. To many it seemed that the fate of the port were hanging in the balance; that if vastly improved facilities for our war commerce should be provided at other ports, and nothing were done at Boston, traffic routes through other ports would become so firmly established during the war that when peace came Boston would find that her prestige as a port had gone forever. The seriousness of the situation and the fact that if anything were to be accomplished Boston must be aroused to the necessity of doing something for herself were impressed upon the directors of the Boston Chamber of Commerce at a meeting in late September, by Mr. H. P. Kendall, a director of the Chamber who had spent some months in Washington as a member of the Storage Committee of the Council of National Defense. Our Chamber of Commerce was quick to appreciate that unless something were done to convince Washington authorities that Boston was a suitable war port, no steps were likely to be taken toward providing a Government port development here, and that Boston's future standing as a port was in jeopardy. Through a special committee, the Chamber began at once the preparation of a report to be submitted to Washington setting forth the actual conditions at this port and the possibilities of utilizing Boston for the storage and shipment overseas of war supplies. While the report was in preparation, Mr. Stuart, chairman of the Committee on Terminal Port Facilities, came to Boston by invitation of a member of the Chamber, inspected our waterfront, and met at luncheon the presidents of the Boston and Maine and Boston and Albany Railroads and the vice-president in charge of the operation of the New Haven Road. These railroad representatives convinced Mr. Stuart, himself a railroad man, that the New England railroad situation was by no means in the decrepit and chaotic condition that had been pictured at Washington; that not only

were these three railroads fully capable of handling the then existing Boston business but that they could take care of a substantial increase as well; and that arrangements would be made between the three roads for the transfer of carload freight from one road to another so that freight from all the roads could be brought to any point on the waterfront which might be selected as a government storage and shipping terminal. These railroad representatives made it plain that their roads desired to cooperate in every way toward the upbuilding of Boston and aiding the Government to win the war.

As the result of his inspection of Boston's waterfront, Mr. Stuart agreed with the Chamber of Commerce Committee that the Commonwealth lands at South Boston were the logical site for a government war terminal. On October 18, 1917, a few days after Mr. Stuart's visit to Boston, the Chamber's report upon the suitability of the port of Boston for the storage and shipment of war supplies was presented and explained at a meeting of the Committee on Terminal Port Facilities at Washington. The report suggested that Commonwealth Pier No. 5, in South Boston, as fine a pier as any in this country, and at that time practically idle, could be utilized immediately not only for overseas shipments but for some storage as well, and that temporary storage warehouses could soon be built upon the vacant Commonwealth lands south of Summer Street, between C and E streets, all of which were readily accessible by rail. After a consideration of this report and the report of the chairman upon what he had found as to conditions at Boston, the Committee on Terminal Port Facilities at this meeting voted unanimously to recommend the selection of Boston as an embarkation port, to recommend the lease by the Federal Government of Commonwealth Pier No. 5 and the utilization of such Commonwealth lands at South Boston as might be found necessary.

On October 20, 1917, a delegation headed by President Harriman of the Chamber, representing the Chamber of Commerce and other commercial interests of New England, the Public Safety Committee of Massachusetts, and including the mayor of Boston and other city and state officials, had a conference at Washington with the Secretary of War, at which the

facts as to Boston were set forth and Boston's value to the country as a war port was urged, but the Secretary was non-committal as to what use, if any, would be made by the Government of the port of Boston. Here the matter apparently ended, for the time being, and we heard nothing further regarding the Government utilization of this port until January of this year.

On January 28, 1918, the speaker was called to Washington for a conference with Major-General Goethals, acting quartermaster-general, and director of storage and traffic, Major (now Colonel) Wells, director of storage, and Major (now Colonel) Gunby, in charge of the engineering branch of the Construction Division of the Army. The Chamber of Commerce report lay upon General Goethal's desk. At this conference the general outlined in brief his ideas as to a Government war terminal at Boston. He was convinced as to the Government's need of this port. He did not believe that the lease or purchase of Commonwealth Pier and the provision of temporary warehouses on the land south of Summer Street, as suggested in the Chamber's report, was the best proposition or one adequate for the Government's requirements. Larger and better facilities were needed, and whatever was provided should be of permanent character, useful not only for the present war but also for future wars should they, unfortunately, ever come. Furthermore, a permanent terminal should be provided which would not only be useful for storing and shipping war supplies but would be equally adapted to commercial uses after the war, should the Government wish to lease or dispose of its property. As the result of his examination of the plans of Boston Harbor, General Goethals suggested that a Government pier be built on the Commonwealth flats just east of the Fish Pier bordering the main ship channel, and that on the land immediately back of the pier the Government should build storehouses of permanent construction providing about two million square feet gross floor area. The speaker was asked to make an investigation and report upon this suggestion.

To General Goethals, then, is due the credit for the inception of the plan which has finally resulted in the Boston Army Supply Base development.

Right here we may explain the relation of General Goethals and the Construction Division of the Army to this project. As director of storage and traffic it was General Goethal's province to determine in a general way the Army's requirements as to storage and shipping facilities; and later, after the facilities were built, to operate the terminal through his subordinate officer, the director of storage.

The responsibility for the design and construction of army plants such as this rests with the Construction Division of the Army, an independent division of the War Department reporting directly through the chief of staff to the Secretary of War. The Construction Division is the outgrowth of the Cantonment Division which was organized in the spring of 1917 to build the great army camps or cantonments throughout the country. The building of these camps was such a notable success that upon the completion of this huge undertaking, in the fall of 1917, the construction work for the Army in this country was turned over to this division which thereafter was known as the Construction Division. It is the Construction Division's function to take the general requirements of the other divisions of the War Department, prepare the necessary designs and carry out the constructions, turning over completed plants to these other divisions to operate. The present head of the Construction Division is Brig.-Gen. R. C. Marshall, Jr., a regular army officer and a man admirably fitted for this post. Under him, the personnel is made up almost exclusively of civilians, trained engineers and able business men, who took officer's commissions after our entry into the war, and by splendid team play built up, in the Construction Division, one of the most effective pieces of war machinery to be found in any country to-day. The several branches of the Construction Division are, (1) the Engineering Branch, under Col. F. M. Gunby, of Boston, a respected member of this Society; (2) the Construction Branch, under the joint charge of Col. M. J. Whitson, formerly of the Stone & Webster organization, and Col. Peter Junkersfeld, late of the Chicago Edison Company; (3) the Materials Branch, headed by Col. J. N. Willcutt, a well-known Boston builder; (4) the Legal or Contract Branch, under Col. Evan Shelby, a New York

lawyer; and (5) the Accounting Branch, under Col. Neville. Boston is well represented in the Construction Division by the officers named and by many others distributed throughout its personnel; indeed, those who have been in touch with Washington affairs during the war have been impressed with the active part Boston men are taking in all war activities — Bostonians are everywhere, and this city has reason to be proud of the important part her sons have taken in the larger problems of the war.

Returning again to the Boston Army Supply Base, the suggestions made by General Goethals on January 28 were studied by the speaker's firm, and on February 6 a report was made to the Construction Division and to General Goethals upon the latter's suggested scheme (Scheme A) and upon another scheme (Scheme B) for a development along the Reserved Channel, South Boston, on the site later purchased by the Government. Ledge rock in the harbor in front of the pier proposed in Scheme A was a serious objection to that scheme, not only in the matter of expense but particularly because of the time required for its removal, which would delay putting the plant into use for shipping purposes. Such geological information as was at hand indicated that ledge rock would not be encountered along the Reserved Channel, and after discussion it was decided by General Goethals that further study should be given to a development along the lines of Scheme B.

From the time that Scheme A was first suggested, on January 28, until the completion of the project according to Scheme Q was finally decided upon at Washington, late in May, a lot of time was spent in running down the alphabet with scheme after scheme worked out to meet the numerous suggestions and varying requirements of the many officials more or less directly concerned with this project. The augmented engineering staff of the speaker's firm worked day and night; and, by special dispensation from Washington, heatless Sundays and Mondays were unknown at their Boston office. Meantime, members of the firm were commuting weekly, sometimes oftener, between Boston and Washington. For a time it did seem as though "too many cooks would spoil the broth," but by April the pre-

liminary studies had proceeded to a point where it was found that, of the several schemes then under serious consideration, certain constructions near the middle of the proposed site were common to all. Accordingly, authorization was made in April of a part of the project, to the extent of about \$14 500 000, and construction of the authorized portion of the storehouse was started April 22 without knowing what scheme would be adopted for the completion of the project. This partial authorization provided for the construction of four of the six sections of the main storehouse, of a corresponding length of wharf and wharf shed, and of railroad trackage, underground structures and other constructions common to the plans then being considered.

To show how readily Washington could change its official mind, it may be mentioned that the April authorization of the first part of the project provided for a storehouse six stories in height, and work on the foundations was started accordingly. Early in May, before these foundations were very far advanced, it began to look as though Washington would decide to increase the height of the storehouse from six stories to eight, and as the number of stories to be carried made some difference in the size of the foundations, those in charge of the project provided foundations for an eight-story building on the chance that the higher storehouse would later be determined upon. Their judgment proved to be correct, and in the second authorization for the completion of the Army Base, made late in May, the storehouse was fixed at eight stories in height by six sections in length. The second authorization, too, provided for a corresponding increase in length of wharf shed, in front of the storehouse, and authorized also the building of the navy pier and pier shed at the easterly end of the site.

The starting of construction before the entire undertaking had even been decided upon naturally made the preparation of the detailed designs a difficult and hurried matter. The contractors were right on the necks of the designing engineers, so to speak, and were insistently calling for plans all through the work up to the signing of the armistice, when overtime work on construction was stopped. At no time was an armistice necessary between the contractors and the engineers, however, for

the contractors were ever mindful of the difficulties which the war emergency imposed upon the preparation of the detailed designs, and they were at all times most considerate and most helpful to the engineers in their work.

In the building of the Boston Army Supply Base the Boston representative of the Construction Division of the Army is Major Charles R. Gow, past President of this Society, who as constructing quartermaster not only has full charge of the entire project but is responsible for all expenditures as well, all cheques for these expenditures bearing his signature. Assisting Major Gow is a staff of subordinate officers and a considerable office force, including the staff of the field auditor, who passes promptly upon all accounts right at the job, thus avoiding the red tape and delay incident to an audit at Washington. The principal contractor is the W. F. Kearns Company, and the leading sub-contractors are Holbrook, Cabot & Rollins Corporation, P. McGovern & Company, T. Stuart & Son Company, the Raymond Concrete Pile Company and the Bay State Dredging Company. The speaker's firm has had charge of engineering and inspection, this work including the making of all preliminary studies and detailed designs, the preparation of specifications, schedules and estimates, the engineering supervision of construction and field inspection, and the preparation of record and operating plans of the plant. The firm of Hollis French and Allen Hubbard, consulting engineers, was associated with the speaker's firm in the preparation of all plans and specifications for the heating system, including the boiler house.

Construction of the project, begun less than eight months ago, is now, on December 18, more than ninety per cent. complete and would have been finished by January had not the signing of the armistice materially slowed down the work. The total authorization for the project, made according to the preliminary estimates of the engineers, is slightly over \$28 000 000, and it is expected that the project will be completed at a figure well within this estimate.

It may be noted that the Boston Army Supply Base was the first important war project of permanent character in which civilian engineers were called upon by the Army for full engi-

neering service, from the inception of the project through the stages of preliminary studies, detailed designs and engineering supervision of construction to the completion of the finished plant. Coöperation of the closest and heartiest kind was afforded these civilian engineers by the Construction Division at Washington, and the latitude allowed the engineers is shown by the fact that every plan made for the project was made by civilians and made in Boston.

Credit for the success and speed with which this work has been carried out is due to several important participants: first, to the Construction Division at Washington for the excellence of its organization on business lines, for its elimination of red tape, and for its national supervision of materials of construction such that the job was always kept supplied with the materials required; second, to the constructing quartermaster in direct charge of the entire undertaking, Major Gow, who, notwithstanding the tremendous responsibilities, has met so efficiently and so well every requirement of a general manager of a business of more than \$25 000 000 magnitude that it may frankly be said that a better selection for this important position could hardly have been made; third, to the remarkably able and efficient organization of contractors, principal contractor and sub-contractors, perhaps as strong an organization of contracting resources and construction talent as has ever been gotten together in this country; fourth, to the staff of engineers and inspectors, who worked loyally days, nights and Sundays, at top speed, through many months, to insure the success of the undertaking; and especially to the resident engineer, Mr. George L. Mirick, who has met every demand made upon him with a spirit and resourcefulness worthy of special commendation; and, finally, to the splendid team play among all concerned — a coöperation remarkable for any big undertaking — a general feeling that the interests of all were common, not antagonistic, and that all were working for a single boss, — Uncle Sam, — for the single purpose of winning the war in the shortest possible time.

BOSTON SOCIETY OF CIVIL ENGINEERS
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THE BOSTON ARMY SUPPLY BASE. — CONSTRUCTION
FEATURES.

BY CHARLES R. GOW,* MEMBER BOSTON SOCIETY OF CIVIL ENGINEERS.

(Presented December 18, 1918.)

THE title of "constructing quartermaster" is somewhat of a misnomer in this instance, because the official entitled to that designation was most fortunate in having assigned to him, as engineers and as contractors, individuals and firms far better qualified than he, both to design and to construct the many features embraced in this project. The functions of the constructing quartermaster, therefore, have so far been confined chiefly to that of official representative of the Government, with a view to coördinating the efforts of those employed in various capacities and to disbursing the funds appropriated for the work.

Having been engaged for approximately twenty years in the business of general contracting, it has been a distinct pleasure to the writer to assume temporarily the opposite rôle of owner's representative, and to exercise the powers and prerogatives which so often, in the past, have been used by others to effect his own discomfort. Incidentally, he has had occasion to verify

* Major Q. M. C., U. S. Army, Constructing Quartermaster.

NOTE. — Discussion is invited, to be received by W. L. Butcher, Editor, 715 Tremont Temple, Boston, Mass., before May 10, 1919, for publication in a subsequent issue of the JOURNAL.

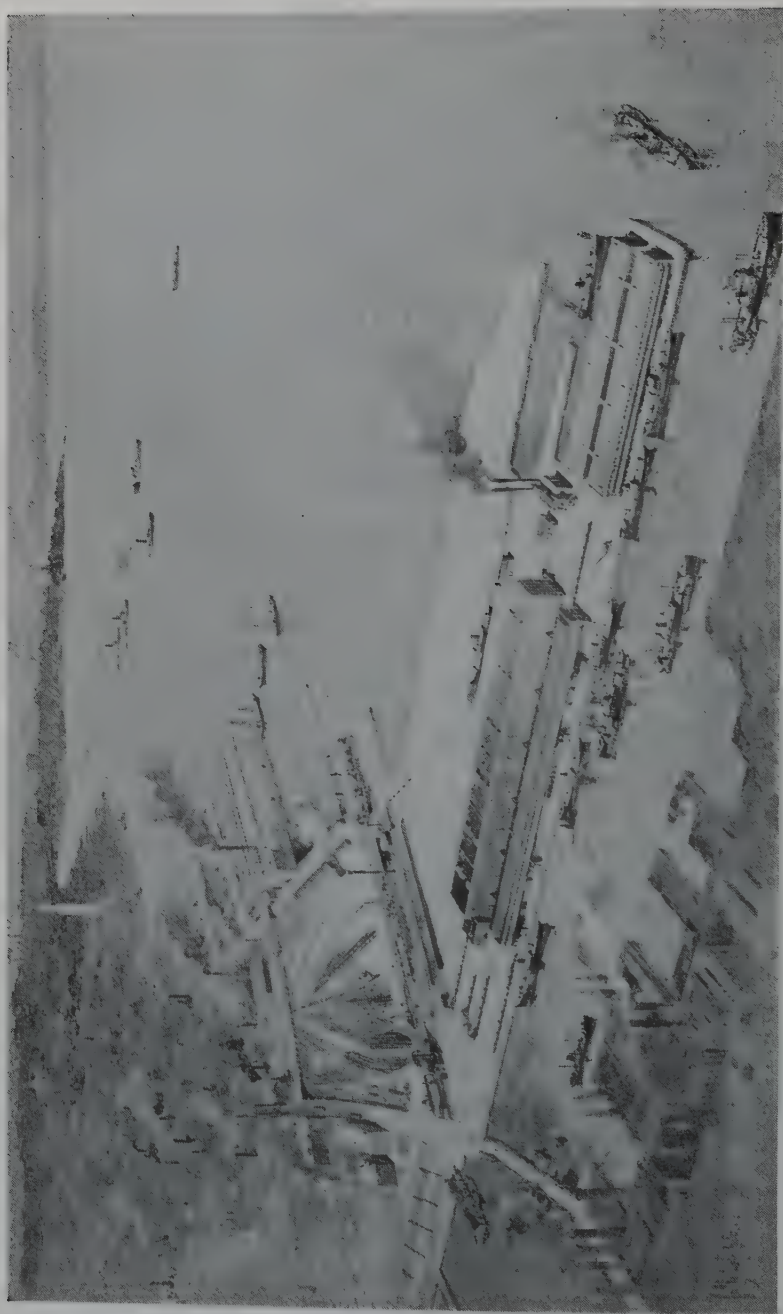


FIG. 1. GENERAL VIEW OF THE BOSTON ARMY SUPPLY BASE.

a suspicion he has strongly entertained for many years, — that it is much easier to instruct others what to do and how to do it than it is to do it yourself. The contractors engaged upon this work have accomplished the desired results so much better, quicker and cheaper than the writer could have done under similar circumstances, that he has many times congratulated himself because to him were assigned the less difficult tasks of the constructing quartermaster.

Turning to the views of the work, Fig. 1 shows a perspective view of the entire project. At the left in the center background is shown the railroad yard, containing a little more than 11 miles of trackage, and allowing storage for approximately 750 cars of freight. The space covered by this yard is about 20 acres. It is located on land owned at present by the Commonwealth of Massachusetts, and is occupied under a permit granted to the Government by the Massachusetts Commission on Waterways and Public Lands. The small building in the left center foreground is the Administration Building, a four-story structure containing about 30 000 sq. ft. of floor area. Immediately to the right of this building is the Main Warehouse, 1 638 ft. long, by 126 ft. wide and eight stories in height. In front of and separated from the Warehouse by a paved street 87 ft. in width, is the Wharf or Cargo Shed, of similar length but only 100 ft. wide and two stories high. The Navy Pier Shed (so called) is shown at the extreme right, a twin structure 924 ft. long, each wing being 100 ft. in width and three stories high. Between the Warehouse and Pier Shed are seen the Power House and Electric Substation. There is a continuous wharf extending from the L Street Bridge, along the Reserved Channel for a distance of 4 100 lin. ft., to the end of the Pier Shed. If to this is added the apron along the east and north sides of the Pier Shed there is a total length of approximately 5 400 lin. ft. of wharf cap, or more than one mile. In order to provide adequate depth of water for docking and berthing vessels along this wharf, there is required the removal of about 2 800 000 yds. of dredging; 35 ft. depth has been provided for berthing space for the first 3 100 ft. in length along the Channel side, with only 30 ft. adjacent to the Pier Shed. There are approximately $6\frac{1}{2}$ miles of trackage

inside the main grounds, for the delivery of cars to the several portions of the project. In addition, there are complete systems of high- and low-pressure water supplies, sewerage and surface drainage, underground conduits for wires, etc.

When the site was purchased from the Commonwealth in April, 1918, it consisted of an undeveloped fill, partly of recent origin, containing approximately 37 acres and in addition about 20 acres of tidal flats. It has been necessary to raise the average level of the filled area about $4\frac{1}{2}$ feet over the entire lot. This has been accomplished by utilizing surplus excavated material and filling brought in on cars and barges.

WAREHOUSE.

One of the most serious questions met with at the inception of the work was that of the desirable type of foundations to be adopted. As previously stated, the site consisted of reclaimed flats hydraulically filled, and this filling, in turn, overlaid a substantial depth of silt and other undesirable material extending to the clay at an average depth of twenty-eight to thirty feet below the surface.

The most important foundations were those required for the Warehouse (Fig. 2), the column loads of which in some instances exceeded 1 000 tons each. To use ordinary wooden piles would necessitate driving between 80 000 and 90 000 such piles under this building alone. This would require continuous spacing over the entire building area on two-foot centers. To cut off these piles at grade 9.00, in order to assure permanent saturation, would necessitate the removal of 50 000 cu. yds. of excavation and the introduction of a distributing mat of reinforced concrete to equalize loads on the several piles. The difficulties of obtaining such a large number of wooden piles in time, together with the expense and delay of excavating and concreting such large quantities, rendered this method prohibitive.

As an alternative, concrete piles were considered. If of the pre-cast type, the time required to make and cure them would condemn the suggestion. Built-in-place concrete piles

were practicable, but only one type was considered sufficiently dependable for so large a job, and this type could not readily be driven in the lengths required to meet these soil conditions.

As a last resort, the caisson type of pier footing was considered, and while the character of the underlying earth was not ideally suited for open excavation processes, it was found that



FIG. 2. THE WAREHOUSE.

this method of obtaining satisfactory foundations for the Warehouse gave greater promise, both as regards speed of construction and ultimate cost, than either wood or concrete piling.

Accordingly, it was determined to adopt the caisson type of footing, carrying down a circular concrete shaft 6 ft. in diameter until a sufficient penetration was obtained in the underlying clay, and to bell out in this material in the shape of a truncated frustum of a cone having inclined sides at an angle of 60 degrees with the horizontal, until a circular base of sufficient area to distribute the load safely was obtained.

It was assumed from an examination of test-boring samples of the clay that a unit loading of 5 tons per square foot at the

base of the caisson footings would not be excessive, and their diameters were determined upon this basis.

The unit compressive stress in the concrete shaft was cared for by varying the concrete mix so that no unsafe limits would be reached. This method was deemed preferable to that of varying the size of shafts, because it allowed a standardization of forms.

The method of constructing these caisson piers is clearly illustrated by Fig. 3. An excavated sheeted pit, about 10 ft. by 10 ft. in plan and 10 to 12 ft. in depth, was first sunk and heavily braced. In the bottom of this pit, a steel cutting edge was accurately centered and leveled. Upon the cutting edge were then assembled an inner and outer set of circular wooden forms, similar to those used in casting large-sized concrete pipe. The outer form was exactly 6 ft. in diameter, while the inner form was 4 ft. 8 ins., thus providing for a thickness of 8 ins. of concrete shell. This shell could be carried up to any desired height, but usually not more than 21 to 22 ft. of shell were concreted at one time.

As soon as this concrete had sufficiently hardened, the outer form was removed, the concrete shell was securely braced to the sides of the open pit by means of four vertical guide timbers, and the sinking process begun. A laborer was lowered into the interior of the shell, who excavated from below the cutting edge, thus allowing the hollow shell to sink under its own weight. This process was followed as long as the shell continued to settle by gravity, usually for a depth of 10 to 15 ft., after which the surface friction between the exterior of the shell and the sticky clay filling became too great to permit further progress by this method.

Four short toggle timbers were then inserted diagonally across and under the corners of the lower set of braces in the open pit, and from these toggles heavy chains were brought up above the ground surface to engage two large jacking beams which served as reactions for four or more 25-ton ratchet jacks, thus increasing the apparent weight of the shells by this amount. (Fig. 4.) A further penetration of the shell was thus obtainable, until the upward pull on the toggles became sufficient to lift bodily the sheeting of the pit, at which stage, of course, no further

sinking was possible by this means. If the clay had not been reached in the meanwhile, it became necessary to poll down below the cutting edge, using short lengths of vertical sheeting which were held temporarily by interior circular rings. A sec-



FIG. 4. METHOD OF FORCING DOWN CAISSON SHELLS.

tion of shell corresponding to the length of polling board used was then built in place, thus underpinning the section previously sunk and forming an extension thereto. This process was repeated until the clay had been reached, after which the bell was

excavated and braced as shown in Fig. 2. The final stage of the process consisted in filling the bell and interior of shaft with concrete, thus providing a solid monolith. Figs. 5, 6 and 7 are views of piers under construction.

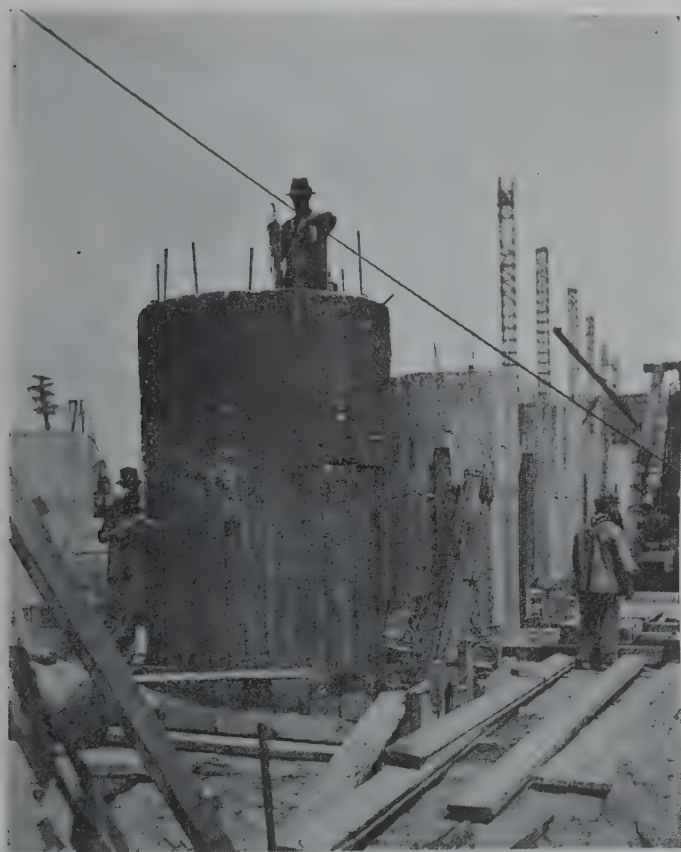


FIG. 5. PIERS UNDER CONSTRUCTION.

It was found necessary, in many instances, to carry these caisson footings as deep as 55 ft. in order to obtain satisfactory material in which to excavate the bell. Many of the footings gave trouble by reason of a tendency of the clay to flow under pressure from adjacent piers.

The general contractor, the F. W. Kearns Company, selected, as its subcontractor for this caisson work, P. McGovern & Company, of New York, a firm having a recognized experience and ability in handling heavy construction work below ground. The



FIG. 6. PIERS UNDER CONSTRUCTION.

wisdom of this selection was fully demonstrated by the remarkable results obtained by this subcontractor. There were 577 caisson footings required, and ground was broken by the subcontractor on April 22. The progress schedule adopted required the

footings to be entirely completed by August 31. Despite the fact that the physical conditions governing this work were much more difficult than originally anticipated, the subcontractor turned over the last finished pier on August 10, three weeks



FIG. 7. PIERS UNDER CONSTRUCTION.

ahead of his schedule. This progress represented an average of five and two-thirds footings completed per day actually worked. The total amount of concrete involved was approximately 38 000 cu. yds. This remarkable progress under the most trying cir-

cumstances was due entirely to the exceptional resourcefulness, ingenuity and all-round ability displayed by the subcontractor's organization. Not only was this difficult work completed three weeks ahead of time, but was also finished within the estimate of cost originally allowed.

The superstructure of the Warehouse consists of reinforced concrete throughout, a total of 90 000 cu. yds. being required in its construction. The building consists of six sections — each 273 ft. long — in a continuous succession, individual sections being separated from their neighbors by a construction joint extending entirely through the cross-section except for the footings, which are common for the two abutting building columns. The first floor is designed for a live load of 500 lbs. per square foot, and all subsequent floors for 300 lbs. per square foot. All reinforced concrete designs are in accordance with the requirements of the so-called Joint Committee rules. The column spacing is 21 ft. by 21 ft., and all floors are of the flat slab type. The first story is 18 ft. in height, and subsequent stories are 14 ft. A twin tunnel runs the entire length of the building under the first floor, for the accommodation of steam pipes, electric conduits, etc. Along the north side of the Warehouse is an unloading platform 23 ft. in width, covered by a suspended canopy of reinforced concrete. Each section of the building is provided with a battery of four Otis freight elevators, each 9 ft. by 17 ft. and capable of lifting a load of 10 000 lbs. at a speed of 100 ft. per minute. These elevators are equipped with an automatic leveling device which adjusts them under all conditions to the exact level of any given floor. The elevator doors are all electrically operated from a central control station. A single passenger elevator of the A. B. See type serves each section of the building. All door openings on the first floor are 16 ft. by 12 ft., and are provided with full-opening Kinnear bifolding doors. The Warehouse is heated by a combination system of hot water circulated through the sprinkler system and by an auxiliary low-pressure steam system of wall radiation. Three stairways are provided for each section, with communicating doors on each floor between sections. A central partition divides each floor area of each section into a unit of approximately 16 000

sq. ft. The Warehouse is designed with a view to its ultimate use as a manufacturing building, and for this reason maximum window openings are provided.

Work on the superstructure of this building was begun by the general contractor, the W. F. Kearns Company, on May 24, and was completed on October 2, a total of 108 working days. This represents an average performance of 900 cu. yds. of con-



FIG. 8. WAREHOUSE IN USE.
Sixth Floor, Section E.

crete poured per day for this structure only, and probably establishes a record for progress on a building of this type. The estimated date of completion was November 30, so that the contractor exceeded requirements in this respect by fifty-nine days. Two construction towers, served by independent concrete mixers, distributed concrete to each section of building. Fig. 8 is a view of the interior as completed and in use.

An interesting feature of construction, and one which greatly facilitated progress, was the system of forms used, especially that for floor slabs. All form work was designed by the contractor's

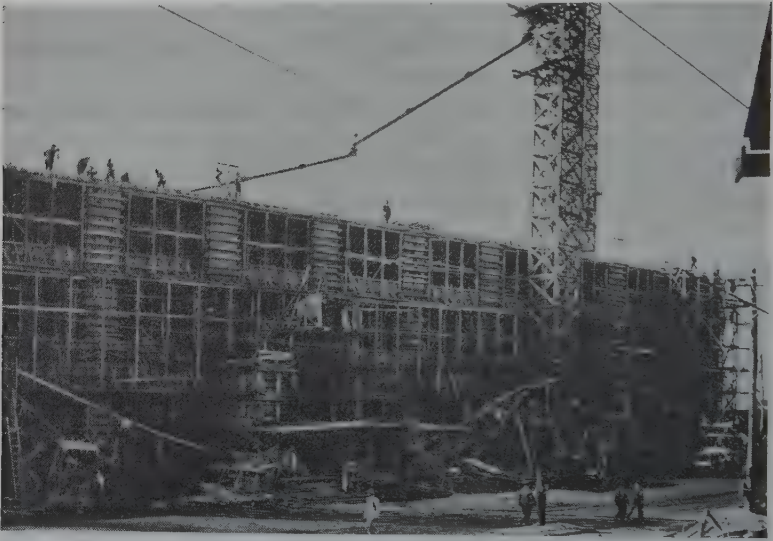


FIG. 9: FORMS IN PLACE.
Warehouse, Section F.



FIG. 10. WAREHOUSE FLOOR FORMS.

engineering force, was fabricated at a sawmill on the grounds, and was routed to position as required. The floor forms consisted of standard mats constructed of 2-in. by 3-in. pieces on edge, with separations between adjacent members into which the 2-in.

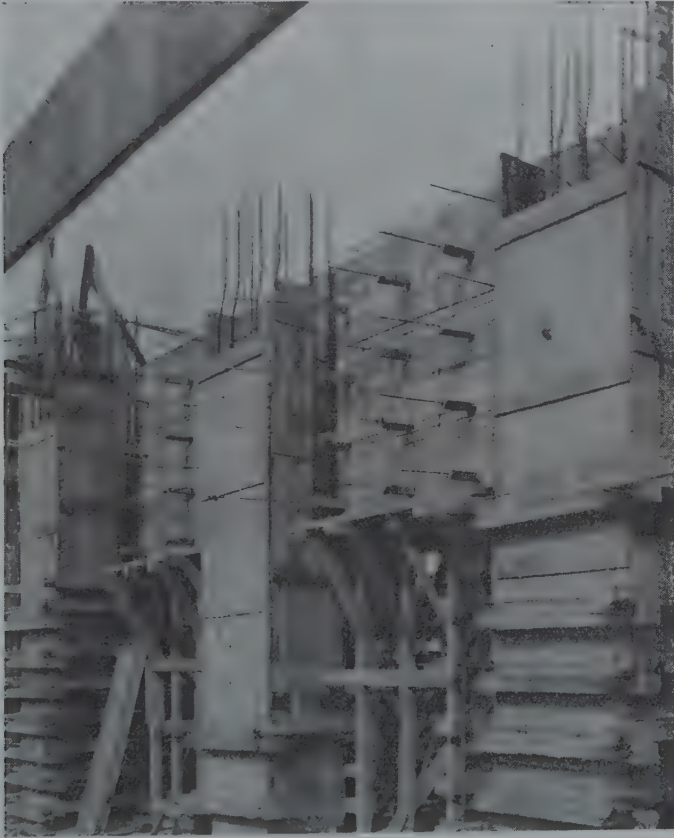


FIG. II. WAREHOUSE COLUMN FORMS IN PLACE.

by 3-in. pieces of abutting mats could be telescoped, and thus provide adjustment of the longitudinal dimension without sawing or special fitting. A succession of these mats was laid over the area to be covered, supported upon 4 in. by 6 in. stringers, and over the top surface of the mats thus assembled was tacked



FIG. 12. PILING OF WHARF SHED PLATFORM.



FIG. 13. WHARF SHED PLATFORM.

No. 22 gage sheet iron, which also could be lapped in any direction to cover a given space without cutting. The rapidity with which these forms could be assembled rendered them especially efficient. An idea of some of these forms in place may be obtained from Figs. 9, 10 and 11. Forms were made and placed for the eight stories of one section of the building, and when stripped they were moved forward horizontally into the next adjacent section. As each section was substantially typical, a set of forms for any one story could be moved to a corresponding position in the next section without alteration. Sheet-metal forms of circular cross-section were designed by the contractor for all typical interior columns.

The completed Warehouse contains approximately 1 600 000 sq. ft. of floor area and occupies about 23 800 000 cu. ft. of space.

WHARVES.

There is a total of 10 acres of concrete wharf embraced in this project. A continuous wharf cap 5 400 ft. in length for the berthing of vessels is provided, 4 100 lin. ft. of which is in a straight line fronting on the Reserved Channel.

Under normal conditions it would probably have been practical to construct a quay wall along the face of this wharf and to have filled behind it, using spruce piling for foundations. The time allotted, however, in this case did not permit of this treatment, and it was determined to support these wharves, and such structures as they carried, upon piling driven in the water. It has been customary to use oak piles in Boston Harbor under such conditions, but, due to an excessive demand for oak piles on other Government work, it was impossible to obtain them in any appreciable quantity. As an alternative, the use of Southern pine piles was adopted. All piles were cut at the level of mean high water, or grade 10. It was assumed that cutting at this level would assure the continuous saturation of the piles. The question of possible worm action was considered, and an examination made of existing piling in the neighborhood, without finding any serious evidences of damage from this cause. All piles were driven with the bark on.



FIG. 14. WEST OPEN WHARF.



FIG. 15. ADMINISTRATION BUILDING, WAREHOUSE AND WHARF SHED.

The piles were driven in transverse bents on 10.5 centers, with special clusters under building columns and other concentrated loads. As stated above, they were cut at grade 10, girder capped, and braced between high and low water, and transverse concrete girders 18 ins. thick, resting on the pile heads, were brought up to the under side of the 10-in. reinforced concrete slab which forms the wharf deck.

All of the wharf work was sublet by the general contractor to the well-known Boston firm, the Holbrook, Cabot & Rollins Corporation, which, by reason of its elaborate water plant and experienced organization, was able to complete the work well within the allotted time.

This work required the driving of 30 000 piles; the use of 2 000 000 ft. B.M. of hard-pine timbering; the placing of 41 000 cu. yds. of concrete, and the assembly of 1 200 tons of steel reinforcing. Figs. 12 and 13 illustrate the successive stages of wharf construction, and Fig. 14 shows the completed stretch of open wharf at the westerly end of the property.

WHARF SHED.

The Wharf Shed (Figs. 15 and 16) is two stories in height, with a monitor roof, the first story being 31 ft. 6 ins. and the second, to top of monitor, 29 ft. 8 ins. On account of the column spacing required, 21 ft. by 33 ft., together with the heavy live loads anticipated, the framework of the Wharf Shed is constructed of structural steel, the only concrete required being in the curtain walls and the floor slab of the second floor. The roof is constructed of plank on wooden purlins, and is covered with tar and gravel. The deck of the wharf, which forms the first floor, is designed for a live load of 600 lbs. per square foot, and the second floor of the Wharf Shed provides for a live load of 400 lbs. per square foot. The concrete wharf deck extends 35 ft. beyond the face of the Wharf Shed on the water side, making provision for the installation of two standard-gage tracks beside an additional track for the wharf cranes. Four thousand one hundred sixty-three tons of structural steel were required for the framework of this building, while only approximately 5 000

cu. yds. of concrete were necessary for the walls and floor. The Wharf Shed is equipped with five elevators manufactured and installed by the F. S. Payne Company, of Boston. Six over-



FIG. 16. WHARF SHED, SOUTH SIDE.

head bridges, one to each section, connect the second floor of the Wharf Shed with the third floor of the Warehouse, thus permitting cargo assembly of goods transferred from the six upper stories of the Warehouse without interference with traffic on Terminal Street, so called, this being the paved roadway



FIG. 17. PIER SHED.



FIG. 18. PIER SHED, SOUTH SIDE.



FIG. 19. PIER SHED FROM SECTION "R."



FIG. 20. INTERIOR OF PIER SHED.

between the two buildings. A projecting balcony is provided at the second-floor level on the water side, for the direct transference of goods from this level to the ships, or *vice versa*.

The Wharf Shed is unheated, except for offices and toilets, and a dry pipe sprinkler system throughout is therefore required.

Two hundred and twenty-nine Ogden vertical-lift doors give access to Terminal Street and the wharf apron on the lower level, and to the open balcony on the upper level.

The structure of this building, containing 328 000 sq. ft. of floor area, was built by the general contractor in a period of ten weeks.

PIER SHED.

The twin buildings at the easterly end of the property, referred to as the Navy Pier Shed (Figs. 17, 18, 19 and 20), are expected to be used by the Navy as general stores for fitting out and repairing ships. It is also possible that it may be used in part as a receiving ship. The building is three stories in height, the first story being 24 ft. and the other two 14 ft. The column spacing is 25 ft. by 21 ft. and reinforced concrete is used throughout for the structural portion of the building, the same general type of construction being used as that adopted for the Warehouse. The available filled area at the site of this building was not sufficient to contain the entire length of the Pier Shed, so that the easterly 100 ft. is built, over the tidal flats and is supported on wooden piles. The balance of the structure rests principally upon clusters of Raymond concrete piles, but the longitudinal outside walls are carried upon a continuous row of pre-cast concrete sheet piling, with some additional Raymond piles immediately in the rear of the sheet piling to carry partially the column loads.

The Raymond type of foundation was adopted for this building because it was found that hard bottom could be readily reached by this means, whereas under the Warehouse the greater depth prevented the use of this type of footing; 6 300 Raymond piles and 4 350 wood piles were required for the foundation of



FIG. 21. CONSTRUCTION OF CONCRETE PILES.



FIG. 22. CONSTRUCTION OF CONCRETE PILES.

this building. The concrete piles are designed for a load of 35 tons each, and are the usual type of pile installed by the Raymond Company. The hydraulic fill forming the first 15 to 20 ft. of soil underlying the site was of very recent origin, and was of such a consistency that it was expected to flow readily unless confined. It was decided, therefore, before dredging for the required deep water adjacent to either side of this building, to



FIG. 23. CONSTRUCTION OF CONCRETE PILES.

drive a continuous row of reinforced concrete sheet piling which should operate as a retaining wall. The piles were pre-cast, were of 18 ins. by 21 ins. cross-section, and varied in length from 37 ft. to 48 ft. Individual piles weighed approximately $8\frac{1}{2}$ tons. They were made with a tongue and groove so as to lock together, and were driven by a 5 000-lb. steam hammer operated by a heavy land machine. Figs. 21, 22 and 23 illustrate the method of forming and casting these piles, in a special yard provided for the purpose on the South Boston side of the Reserved Channel. The contract for making and driving these piles was let to the Raymond Concrete Pile Company, and

Figs. 24 and 25 illustrate the process of handling and driving, while Fig. 26 shows a section of completed bulkhead. These piles were designed to act as vertical beams, being secured at the bottom by their penetration below the dredging line, and at



FIG. 24. HANDLING CONCRETE PILE.

the top by a tie system which extended entirely through the building and which bonded the heads of these piles into the floor system. The length of pile exposed to beam action is about 25 ft. A heavy distributing beam encases the tops of these piles

and constitutes the footing support for the outer walls of the buildings.

Three railroad tracks feed the two wings of this building through an open courtway running longitudinally between the



FIG. 25. DRIVING CONCRETE PILE.

two halves, while the water side is equipped with a concrete apron supported on wood piles, the deck being 28 ft. in width and containing a standard-gage track connecting with the yard system. A loading balcony is provided at both the second and



FIG. 26. SECTION OF COMPLETED BULKHEAD.

third floor levels on the water sides, to facilitate direct loading or receiving to and from ship. Cargo masts are to be provided, secured to the roof at frequent intervals, for the handling of freight.

There are 72 doorways communicating with the track platform, while the water side is provided with 166 Ogden vertical-lift doors.



FIG. 27. CROSS-SECTION OF PIER SHED.

Eight freight elevators serve each wing of the Pier Shed, having a capacity of 12 000 lbs. each and a speed of 50 ft. per minute. The elevators of the south wing are of the Otis type, while those of the north wing are made and installed by the A. B. See Company.

The second and third stories of the Pier Shed are heated by a forced hot-water system, the water being heated largely by exhaust steam available at the Power House, and is conducted to the second story through insulated overhead pipe lines. The lower story is unheated.

A dry system of sprinklers is used throughout the building.

The concrete required for the superstructure of this building was poured by the general contractor in ten weeks.

Fig. 27 shows a cross-section of the Pier Shed illustrating the various features described above.

POWER PLANT.

Fig. 28 illustrates the Power House, a structure 80 ft. by 85 ft., and 78 ft. high. It is built partly upon wooden and partly upon Raymond concrete piles, the latter proving too short to reach good bottom under a portion of the building. The roof is constructed with a structural steel framework supporting the concrete.

The Power House contains six Heine safety boilers of 400 h.p. each, operated by forced draft and using mechanical stokers. The chimneys are twin stacks 165 ft. high and 9 ft. in diameter. An overhead coal bunker with a capacity of 700 tons, feeds coal through automatic weighing machines to the stokers. Coal is received by car, unloaded into an underground hopper, and elevated by means of a conveyer plant to the bunker. All ashes are removed by means of a steam jet conveyer to an overhead ash-pocket, from which they are delivered to cars for removal. The stokers are made by the Combustion Engineering Company, and the coal-handling apparatus is manufactured and erected by the Mead-Morrison Manufacturing Company, of Boston.



FIG. 28. POWER HOUSE.



FIG. 29. ADMINISTRATION BUILDING.

ELECTRIC SUBSTATION.

The Electric Substation consists of a building 86 ft. by 54 ft., containing one story and a basement. It is built of reinforced concrete with brick curtain walls, and will contain six 13 000-volt transformers, two 500 kw. rotary converters, and three switchboards. In the basement are located three motor-driven fire pumps of 100 h.p. each, and a motor generator set and storage battery equipment for operating remote control switches.

ADMINISTRATION BUILDING.

The Administration Building (Fig. 29) is 122 ft. by 88 ft., of reinforced concrete, and consists at present of three stories and a basement, although the design contemplates a future addition of three more stories. It is built upon wooden piles, and is of reinforced concrete throughout with the exception of office partitions, which are built of terra-cotta. The basement will contain a first-aid room, telephone central station, officers' showers, etc. The first and second floors are divided for office space, while the top floor is intended for open desk space.

RAILROADS, ROADS AND UNDERGROUND WORK.

As previously stated, there are required approximately 18 miles of standard-gage railroad tracks. The Russian type of T-rail was adopted throughout, weighing $67\frac{1}{2}$ lbs. per yard. Although somewhat light, this type of rail was available in large quantity at the time work began, whereas the heavier types of rail could not be obtained in quantity in any reasonable season. Fig. 30 is a general view of the railroad yard.

There is a complete surface drainage system for draining the entire area occupied, and the railroad yard is drained by an independent system.

The sewerage system consists of a main sewer about 5 000 ft. long, and varies in size from 6 ins. to 18 ins. Connection was made with the city of Boston sewerage system at Summer Street and E Street. The capacity of the sewer at the point where it



FIG. 30. RAILROAD YARD.



FIG. 31. TERMINAL STREET.

leaves the Army Supply Base grounds is approximately 1.6 sec.-ft., and at the point of discharge is about 3.5 sec.-ft.

The water supply is taken entirely from the city of Boston system, by means of four independent extensions from that system, each line being 16 ins. in diameter. Two of these lines are low service, with a normal pressure of from 50 to 55 lbs. per square inch; and two are of high pressure, varying from 90 to 95 lbs. This arrangement provides for practically four independent sources of supply, reducing danger of interruption of service to a minimum. The high-pressure system is carried around the property in the form of a loop, with branches to the several buildings, and this system is depended upon to supply sprinkler systems, fire hydrants, wharf hydrants, and, if necessary, the domestic service such as plumbing, drinking and boiler feed. In case of failure of both high-service lines, the three electrically driven pumps in the Substation may be operated to maintain pressure on these lines within the grounds, drawing the water supply from the low-pressure system. The freight yard is also protected by a system of hydrants connected with the low-service line.

A paved roadway connects Terminal Street (Fig. 31) with Summer Street, and forms the main vehicle road to the premises. It is expected that Dry Dock Avenue, which is now laid out as a thoroughfare and which skirts the property immediately to the north, will be paved this coming season, and by means of cross-connections will establish a circulating medium for road traffic. All roads on the property are of granite block paving. It is expected eventually to provide a concrete base, but the installation of this base was not deemed desirable until after the ground has had an opportunity to reach its maximum settlement under traffic. Altogether, 28 000 sq. yds. of granite block paving are required.

All of the railroad, roadway and underground work has been sublet by the general contractor to the T. Stuart & Son Company, of Newton, a firm of engineering contractors well known in this locality for the many difficult and extensive contracts of that nature which they have handled. Although this work has not been of as spectacular nature as that involved in

some of the foundation and superstructure work, it is safe to say that without the energy, resourcefulness and all-round ability of this subcontractor, the completion of the work would have been greatly delayed. In addition to the work enumerated, this contractor provided and installed some 50 000 cu. yds. of ballast, laid 50 000 sq. yds. of wood block paving in the several buildings, constructed and operated a gravel and sand screening plant for the production of approximately 1 000 tons of concrete material per day, and in addition operated all of the railroad lines with respect to the receiving and delivery of freight consigned to the work. In this connection it is interesting to note that while approximately 7 500 carloads of freight were received for use in this work, not a single day's demurrage accumulated, and the average period of time required between the receipt and re-delivery of a car was approximately twenty hours.

DREDGING.

In order to provide adequate approaches and berths for vessels in connection with the 5 400 lin. ft. of wharf frontage, there was required the removal of approximately 2 800 000 cu. yds. of dredged material. The contract for this work was awarded to the Bay State Dredging Company, of Boston, which company, besides supplying its own entire plant, arranged with three other dredging contractors for sufficient plant to remove the amount of material called for within the required period. The average daily progress maintained has been approximately 10 000 cu. yds., all of which material has been used by the Commonwealth for filling areas under development by them.

GENERAL.

The entire project was estimated, at its inception, to cost \$28 000 000, and with the work 95 per cent. completed it now appears that the final cost will be well within that figure.

It was expected that the buildings would be ready for occupancy by January 1, 1919. As a matter of fact, the first goods were moved into the Warehouse on October 25 of this year. The Warehouse is now practically under full use, the Wharf Shed

is ready for occupation, and only a few weeks' work remains to be done on the Pier Shed before that also will be ready for use.

Credit for the successful carrying out of this enterprise is due primarily to the general contractor, the W. F. Kearns Company, which company has shown remarkable ability and wisdom in the organizing of the working force, the adoption of methods and the selection of subcontractors. A second contributing cause was the spirit of coöperation and the mutual team play which has existed from the beginning between the contractor, the subcontractors, the supervising engineers and the Government representatives.

Each of the contractors, as already noted, has discharged his duties in an exceptionally able manner, but this would not have been possible were it not for the splendid work done by the supervising engineers, Messrs. Fay, Spofford & Thorndike, and their very able field organization headed by Resident Engineer George L. Mirick. The preparation of detailed plans and the construction work started simultaneously. It was necessary, therefore, for the engineers to work faster on their design than the contractors were able to construct. In spite of this fact, there has been no serious delay at any time because of lack of detailed plans, and the engineering work has been so thorough in preparation and execution that the total sum involved in making changes due to mistakes or interferences on plans has not aggregated one thousand dollars on the entire work. The field organization, in addition to the usual duties, has prepared all schedules, established all lines and grades, inspected both materials and workmanship for quality, and exercised a general oversight of all details of construction.

FORM OF CONTRACT.

The general contract and the subcontracts for foundations, wharfs, railroads and underground work, electrical, plumbing and heating work, were of the so-called "Emergency" type developed and used by the Construction Division of the Army, wherein the contractor is reimbursed by the Government for all direct expense incurred for labor and materials, and, in addition, is allowed a fee, the amount of which depends upon the total

disbursements but is figured at a decreasing rate as the cost increases. There is also stipulated in each contract a maximum fee, which is determined in advance, on the basis of an approximate estimate of the probable cost of the work. The largest fee allowable on any contract is \$250 000, which normally would be earned under the sliding scale when \$10 000 000 had been expended, and no greater fee is permitted, regardless of the total amount ultimately spent.

Thus, in this instance, if the estimated total of \$28 000 000 expenditure were finally reached, the general contractor would earn his maximum fee at \$10 000 000, and thereafter would be obliged to do the remaining \$18 000 000 of work without profit. The average percentage of profit for the entire job in such a case would be about .9 of one per cent.

Inasmuch as certain overhead and establishment charges, including the cost of financing, are not included in the figured costs, it will be seen that the net profit to the contractor is even less than that stated.

The maximum fee allowable on subcontracts, as has already been stated, is fixed by a preliminary assumption of the anticipated cost of the work to be done, so that if the final cost exceeds the expected cost there is no gain to the contractor.

The largest rate of percentage used in estimating fees is 7 per cent., and this applies only to contracts involving an expenditure of less than \$100 000. A gradual reduction in rate occurs up to the \$10 000 000 limit, at which point the rate has been reduced to 2.5 per cent.

However opinions may differ as to the relative merits of this form of contract, it has proven most successful in this case. Each contractor has taken pride in keeping his costs within the original estimate, and has contributed his personal services freely and effectively for this purpose. In fact, the contractors have, in the main, shown quite as much interest in economy of expenditure as have the Government authorities.

On the other hand, the Government has had unrestricted opportunity to direct all features of the work as it might desire, to change plans or to add and deduct work without involving itself in claims, arguments or litigation.

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It is safe to say that under no other form of contract could this work have been so quickly and economically completed.

The several contractors employed on the various features of the work were as follows:

Contractor.	Character of Work.	Approximate Amount of Contract.
W. F. Kearns Co.	Superstructure and general contract.	\$28 000 000.00
Bay State Dredging and Contracting Co.	Dredging.	1 000 000.00
William Bayley Co.	Steel sash.	10 000.00
Cleghorn Co.	Heating.	500 000.00
Detroit Steel Products Co.	Steel sash.	60 000.00
P. W. Donoghue	Plumbing.	250 000.00
John C. Finegan	Roofing.	75 000.00
General Fire Extinguisher Co.	Sprinkler work.	350 000.00
Holbrook, Cabot & Rollins Corp.	Wharves.	2 000 000.00
Kinnear Mfg. Co.	Steel doors.	76 000.00
Edwin C. Lewis, Inc.	Electrical work.	1 250 000.00
P. McGovern & Co.	Storehouse foundations.	1 500 000.00
Mead-Morrison Mfg. Co.	Coal-handling machinery.	40 000.00
New England Structural Co.	Structural steel.	400 000.00
J. Edward Ogden Co.	Steel doors.	400 000.00
Otis Elevator Co.	Elevators.	600 000.00
F. S. Payne Co.	Elevators.	50 000.00
Raymond Concrete Pile Co.	Pier Shed foundations.	1 500 000.00
Rust Engineering Co.	Chimneys.	12 000.00
A. B. See Electric Elevator Co.	Elevators.	92 000 00
T. Stuart & Son Co.	Railroads, streets and underground work.	1 750 000.00
Warren Bros. Co.	Bitulithic paving.	35 000.00
<i>Consulting, Designing and Supervising Engineers.</i>		
Fay, Spofford & Thorndike.		\$500 000.00
<i>Associated Engineers on Heating and Sprinkler Work.</i>		
Hollis French and Allen Hubbard		\$45 000.00

The work is being done under the jurisdiction of the Construction Division of the Army, of which Brig.-Gen. R. C. Marshall, Jr., is chief; Lieut.-Col. R. M. White, section chief in charge of terminals; Major Clinton F. Fisk, supervising constructing quartermaster; while the writer has served as constructing quartermaster on the job.

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**THE BOSTON ARMY SUPPLY BASE. — FROM THE
CONTRACTOR'S STANDPOINT.**

BY WILLIAM F. KEARNS,* MEMBER BOSTON SOCIETY OF CIVIL ENGINEERS.

(Presented December 18, 1918.)

It is, I think, needless for me to say that to Major Gow, more than to any other one man who is connected with the work in Boston, is due the great success of the job. In the early stages of the work, he was there at all hours of the day and night. Frequently he and I left the job at twelve and one o'clock in the morning, particularly in April in the first stages of the caisson work, which, as he has said, was quite difficult. It seemed at one time a very serious question whether or not we would ever be able to get those caissons down, but the Major stuck to the job, with Andy Cohill, chief engineer of the McGovern Company, and they got them down; but as he has already told you, he doesn't know anything about it.

In other matters, particularly in labor matters, if somebody doesn't get hold of him before the Government makes a contract with him, they will miss getting one of the greatest labor adjusters there is in the United States.

* Of William F. Kearns Co., General Contractors.

NOTE. — Discussion is invited, to be received by W. L. Butcher, Editor, 715 Tremont Temple, Boston, Mass., before May 10, 1919, for publication in a subsequent issue of the JOURNAL.

When, as it frequently happened, we had a great many labor matters to settle, innumerable little questions coming up about the rights of the men on the job and where Union rules were invaded, the Major was there with the smile and a decision. Every Tuesday and Friday, we would have an evening session with the labor men.

As far as our associations with the architects and engineers were concerned, it was simply a pleasure to work with them. There could not be a more efficient organization. There could not have been a more ready response to our needs and requirements in the way of making plans, and sometimes, I confess, we may have been rather unreasonable in wanting plans before we were really ready for them.

I remember one evening we had a conference in the Major's office with the engineers, Mr. Fay, Professor Spofford and Mr. Thorndike, and we wanted a set of plans for some particular object. I think we wanted to get our forms made up ahead of time, or something of that kind, and I tried very hard to get a promise from Mr. Fay as to when we would get the plans, and Mr. Fay had almost fallen for it, when Professor Spofford stepped into the breach and said, "Don't you promise him anything. If you say one week, he will be after them to-morrow and you will have to give them to him."

Referring to our own organization, we were, of course, a comparatively small building concern when we started and we had a force capable of handling, by working hard, probably a million dollars' worth of work a year, when we were confronted last April with the project of a twenty-eight million dollar job. It was some proposition to build up an organization to meet the requirements. I must say we did not need to advertise for the men to fill the jobs.

There were plenty of volunteers. In fact, I think there were over five thousand. It was rather difficult even then to select from such an enormous number of applications, but we did finally put together an organization, the whole theory being to place some individual in charge of a certain given piece of work and not interfere with him so long as he carried on that piece of work efficiently, but the moment we saw signs that he was

breaking down, or that that particular piece of work was going badly, there was an immediate change.

We had a wonderful organization; the results obtained were, I think, remarkable; and I will say this for the organization as it has stood during the last three or four months, including all the subcontractors that we selected to do the work — that if I had to do the work all over again or start a similar job, I would not make a single change in any department, particularly the subcontractors. Every one carried out more than they were asked; every one of them gave the greatest support to the constructing quartermaster and the contractor; everybody worked with the one idea of getting the work done. They did not stop to argue about it. They simply got their orders and they carried them out cheerfully and loyally.

I expected, in bringing together so many organizations, as we did, to see a great deal of friction — and it was amazing how little there was. Every organization carried out its own work and at the same time coöperated with others with whom they came in contact.

The same thing held true throughout our own organization. The employees of the Quartermaster's Corps, of which there were three or four hundred, coöperated splendidly with us and helped us in every way possible.

The Inspection Corps of the engineers were never unreasonable, and they seemed to have the idea that it wasn't a place for faultfinding, — rather it was a place for constructive criticism and assisting the contractors, and they carried that spirit throughout the job.

One of the greatest things that was put into effect there — and I think to Major Gow is due the most of the credit — was the timekeeping system. A card was issued, which was marked into squares, indicating the morning and afternoon hours. As the man passed through the turnstile the card was time stamped. When he reached the job, the foreman of the gang to whom the man was assigned punched the ticket. During the middle of the forenoon, or in the course of the forenoon, the Government timekeeper punched the card again, to show that the man was on his work. Some time in the afternoon, the Government

checker punched the card again; a few minutes before quitting time the foreman again punched the card; and then it was finally time stamped at the gate as he left.

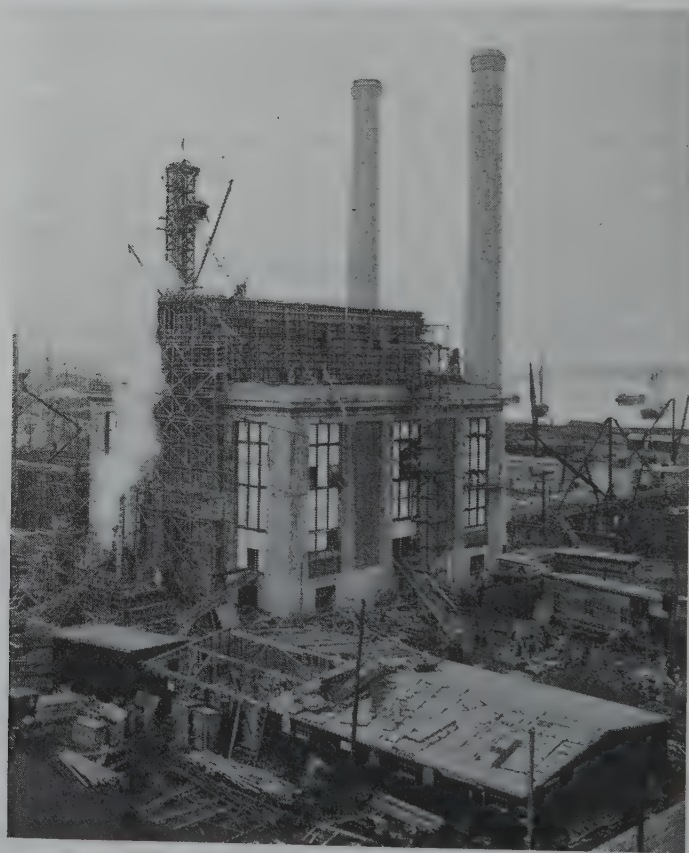


FIG. 1. POWER HOUSE UNDER CONSTRUCTION.

So, practically at every hour of the day, we had a record of every man on the job, and I think there was less trouble in timekeeping on this job than on any similar job I have ever seen. We had a complete daily record of each man through the different punch marks, each foreman having a different die. By this

method we knew just which foreman he was working under, and knowing the foreman, we, of course, knew the kind of work he was doing, so that when the cards were turned in they assisted not only in keeping the time, but in making up the cost records.

The dredging item has not been touched upon, not through any desire not to give credit, I am sure, but possibly other points of interest were more in the speaker's mind. I want to give credit to the Bay State Dredging Company for the remarkable work that they have done in the dredging. They certainly have accomplished wonders, and it looks now as if they would be able to beat us in finally cleaning up on the contract, although at one time they thought they would be on the job two or three months after us.

There are just a few pictures that the gentleman who did not know anything about the construction left for me to explain. Fig. 1 shows the power house, with the stacks above. There wasn't very much to this, except at one time a little difference of opinion as to whether the Greek style of architecture or Italian Renaissance would be the best to use. I think it was finally decided to stick to old colonial.

The power-house installation consists of six 400 h.p. Heine water-tube boilers, equipped with steam-driven automatic stokers and forced draft fuel economizers guaranteed to operate the boilers at 150 per cent. of their normal rating.

Fig. 2 is an interesting picture which illustrates very forcibly the speed with which the work was carried along. In the background of the photograph on the left can be seen, about one half concreted, the eighth floor of Section C of the main warehouse; the fourth floor of Section D in about the same condition; the first floor of Section E about completed, and Section F just started. That was the condition of the Warehouse on August 22.

On October 2 (Fig. 3), just thirty-five working days later, the roof of Section F was finished, completing the concrete structure of the main Warehouse. In other words, twenty-four floors completed in thirty-five days.

This undoubtedly is the fastest piece of concrete construction on record. It must also be taken into consideration that the main objective on this work was the speedy prosecution of



FIG. 2. WAREHOUSE UNDER CONSTRUCTION (AUG. 22, 1918).



FIG. 3. WAREHOUSE NEARING COMPLETION (OCT. 2, 1918).

the project as a whole, and not the concentration of the working forces on one item of the construction alone at the expense of others, so that although a magnificent showing had been made on the concrete work, when that was done, there remained not an empty shell of a building, but everything necessary to complete the entire work. So that on October 23, or three weeks later, the Government took possession of a large portion of the Warehouse, with its railroad facilities, paved roadways, wharf and wharf shed, as a storage base for millions of dollars' worth of wool. This is a record of which we are justly proud.

I think the speed on the work is due more than anything else to the method of forms that we used, as it is very well known that rapid concrete construction is generally dependent on the quickness with which the forms may be fabricated, erected and stripped. With this in mind we studied our form work very carefully, and instituted very successfully two radical changes in the usual method of form building.

In the first place, the study of the difficulties involved in the foundation work of the Warehouse revealed the fact that there probably would be three to four weeks between the completion of the caisson work on the first and second sections, and at least three weeks between the second and third, and so on through the remaining sections, the interval being cut down, as the work developed over more area, never getting less than a week or ten days. Taking advantage of this construction feature, we built a complete set of forms for every floor in Section A; then, in the interval, before the next section was ready, we stripped the completed section and moved the forms horizontally to the same floor of the section ready to be formed.

By working this way, we eliminated rebuilding the form work, as would have had to be done to meet the various requirements of the different floors if the forms had been moved up; we saved the cost of the labor that would have been necessary for such movement, and, in addition, there was a saving of at least a million feet of lumber.

Our second change was necessitated by the confined working space at the site of the building. On account of this, it was necessary to construct all the forms at a central mill, and dis-

tribute them to the work complete in every detail, so that the men on the buildings were merely erectors, in fact, the fabrication and erection of all the form work was handled exactly as is structural steel in a building or bridge.

The forms were marked at the mill where they were fabricated, to correspond with the key or erection plans prepared by our form-design department. Columns carrying the mark "C" and their designating number; beams, "B," beam bottoms, "BB," etc. Thus when the forms were delivered at the job, a glance at the key plan told the foreman exactly where the pieces were located, and a very small organization kept the mill constantly informed just what was wanted at each particular part of the job, so that pieces not needed for some little time were not lying around and going astray. In addition, this system of form handling avoided all confusion in moving the forms from one section to another, as typical pieces carried the same mark through the entire construction. Therefore it made no difference from what part of some other building a foreman secured his form, if it carried the marking of the piece he wanted, it fitted his work. Then again, in case a piece was destroyed in stripping, the mill was notified of the number of the piece, and a new one was made and sent to the work.

In the design of the form work, we used the same method of flat slab centering which we have found very economical in our previous experience. The typical floor frame consists of wooden mats 2 ft. 6 ins. wide by 12 ft. 0 in. long, made up of 2 by 3's placed 5 ins. on center and covered with 20-gage black sheet steel. These mats are supported on 4 by 6 girts approximately 5 ft. on center, and the girts held up by 3-in. by 4-in. posts, 5 to 6 ft. on center according to requirements of the work.

This type of framing, if well made up so as not to be racked and twisted when stripped, can be used at least ten times, and the sheet metal which is rolled after each usage is good for twelve to fifteen uses. The exterior column forms were constructed of 2-in. spruce plank, and special care was used in their fabrication so that the forms would be extra strong; and with very few exceptions, these forms were used in all the sections of the Warehouse, making in all about six times that they were set up. On

the interior round columns, we were able to add to the general appearance of the interior of the building and at the same time effect considerable economy by manufacturing our own metal column forms instead of leasing the ordinary commercial product.

I think the Major has covered the rest of the ground so well that there is nothing really of any importance left for me to say. I want to thank you all for your attention, and hope that we shall have another job, later on, that, while possibly not quite so big, will give us a chance to show that we can speed up even a little more.

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THE BOSTON ARMY SUPPLY BASE.—GENERAL DATA.

BY CHARLES M. SPOFFORD,* PRESIDENT BOSTON SOCIETY OF CIVIL ENGINEERS.

(Presented December 18, 1918.)

Purpose. — The Boston Army Supply Base was designed for storage and shipment of overseas army supplies. It may be used in times of peace as a base for the Emergency Fleet, and the large Storehouse is suitable for either manufacturing or storage.

Location. — The Boston Army Supply Base is located at South Boston, on the southerly side of a strip of filled land lying between the "Reserved Channel" and the main ship channel and adjoining the Commonwealth Dry Dock. The entrance to the site is on Summer Street Extension and is about one mile from the South Station from which it is reached by street car. There is a short and easy approach from the open sea by the main ship channel to the "Reserved Channel."

Area of Site. — The site consists of 57 acres. Before construction began, 37 acres of this was filled land and 20 acres water-covered flats.

Buildings. — The principal buildings are the Storehouse, Wharf Shed and Pier Shed. Minor buildings are the Boiler House, the Electric Substation and the Administration Building.

* Of Fay, Spofford & Thorndike, Consulting Engineers, 308 Boylston St., Boston, Mass.

NOTE. — Discussion is invited, to be received by W. L. Butcher, Editor, 715 Tremont Temple, Boston, Mass., before May 10, 1919, for publication in a subsequent issue of the JOURNAL.

The Storehouse is an eight-story reinforced concrete building, 126 ft. wide and 1 638 ft. long. It is divided into six equal sections, separated by fire walls, with provision for expansion between sections, and is so constructed and equipped that it may be used for either manufacturing or storage. The lower floor has a wood block pavement, and all other floors have granolithic surfaces.

The Wharf Shed adjoins the Storehouse on the southerly side and is connected to it by six bridges, one at each section of the Storehouse. Between the Storehouse and the Wharf Shed is an 87-ft. paved street called Terminal Street, the surface of which is flush with the lower floors of both the Storehouse and the Wharf Shed. The Wharf Shed is a two-story structure, 100 ft. wide and 1 638 ft. long, with steel frame and concrete curtain walls. The balcony at the second-story level permits of transference of freight between this floor and the ship. One of the rails for the semi-portal gantry cranes which are to serve the Wharf Shed is located below the balcony. The pavement on the lower floor is wood block; on the upper floor, bitulithic, and on the balcony, concrete.

The Pier Shed is located at the easterly end of the property and is intended to be used for naval stores. It consists of two three-story reinforced concrete parallel buildings, each 100 ft. wide by 924 ft. long and connected by bridges at the second and third floors. The depressed way between these buildings has a net width of 37 ft. and provides for three railroad tracks; inclined ramps furnish access to ground floors of buildings. The Pier Shed buildings have balconies at the second and third floors on the sides adjoining the water, so that freight may be transferred directly between either of these floors and ships.

Floor Areas (measured to building line). —

Storehouse	— 8 floors @206,388 =	1,651,104 sq. ft.
Wharf Shed	— {1st floor@163,800 = 2d floor @154,960 =}	318,760 sq. ft.
Pier Sheds	— 3 floors @184,800 =	554,400 sq. ft.

Total 2,524,264 sq. ft.

Net Floor Area in Typical Cases. — Percentage reduction in typical floor areas due to various causes:

	Storehouse. All Floors except 1st and 3d.	Wharf Shed. 2d Floor.	Pier Shed. 2d and 3d Floors.
Walls.....	1.6	0.2	1.9
Columns.....	0.9	0.1	0.4
Pipe shaft.....	0.5	0.0	0.0
Radiators, piping, etc.....	0.6	0.5	0.9
Freight elevators.....	3.0	1.1	2.5
Turning space around freight elevators....	12.8	4.9	7.9
Passenger elevators.....	0.2	0.0	0.0
Stairways.....	1.9	0.9	0.9
Offices.....	0.0	1.0	0.0
Toilet.....	0.4	0.0	1.4
Totals.....	21.9	8.7	15.9
Aisles — as laid out for maximum storage (one kind of goods only per section floor),	11.9	20.9	22.7
Aisles — as laid out for miscellaneous storage.....	20.4	25.2	25.8

Total Floor Areas Available for Storage (maximum area after deducting for aisles, assuming only one class of goods stored per section floor and consequently a minimum number of aisles).—

Storehouse.....	1,071,000 sq. ft.
Wharf Shed.....	227,000 sq. ft.
Pier Sheds.....	341,000 sq. ft.
Total.....	1,639,000 sq. ft.

Story and Building Heights. —

Storehouse — Lower story, 16 ft. 0 in. floor to ceiling. 14 ft. 0 in. floor to sprinkler pipes.
Other stories, 13 ft. 0 in. floor to ceiling. 11 ft. 0 in. floor to sprinkler pipes.
Total height of building — End sections 115 ft. 6 ins. lower floor to top of roof (average). 118 ft. 11 ins. lower floor to top of cornice. 122 ft. 9 ins. lower floor to top line of parapet.

Wharf Shed — Lower story, 30 ft. 11 ins. to underside of slab.
 29 ft. 3 ins. to underside of beams.
 27 ft. 0 in. to underside of girders.
 Sprinkler pipes are above bottom of girders.
 Upper story, 20 ft. 7 ins. to underside of roof planking.
 19 ft. 7 ins. to underside of purlins.
 18 ft. 0 in. to underside of roof beams.
 Sprinkler pipes are above bottom of roof beams.

Total height of building — 61 ft. 3 ins. lower floor to top of monitor.

Pier Sheds — Lower story, 24 ft. 0 in. floor to ceiling.
 22 ft. 0 in. floor to sprinkler pipes.
 Other stories, 14 ft. 0 in. floor to ceiling.
 12 ft. 0 in. floor to sprinkler pipes.

Total height of buildings —
 55 ft. 3 ins. lower floor to top of roof (average).
 56 ft. 2 ins. lower floor to top of parapet.

Windows. — The Storehouse has 744 large windows, each 16 ft. $1\frac{1}{2}$ ins. wide and 10 ft. $3\frac{1}{8}$ ins. high; Fenestra steel sash is used, with factory ribbed glass at ends and north side and rough wire glass on the south side. Panes of clear glass are inserted in the lower portions of each window, and 18 per cent. of the total window space is provided with ventilating sashes. The Pier Sheds have a total of 244 large windows on the north and south sides, each opening being 18 ft. 0 in. wide and 5 ft. 2 ins. high; Fenestra steel sash and rough wire glass with occasional panes of clear glass are used and 13 per cent. of the total window space is provided with ventilating sashes.

The Wharf Shed has 142 large windows on the north and south sides of the second floor, with openings 16 ft. $1\frac{1}{2}$ ins. wide and 6 ft. $10\frac{3}{8}$ ins. high. The sash is the Bayley Springfield type, with factory ribbed glass and without ventilation.

Bifold metal freight doors in all of the buildings are provided in the upper half, with wire glass lights.

Freight Doors in Main Buildings. — All doors are of steel. All bifold doors have wire glass lights in upper sections.

Storehouse:

Location.	No. of Doors.	Type.	Size of Opening.	
			Width.	Height.
Lower floor — south.....	56	Kinnear bifold.	16 ft. 1½ ins.	12 ft. 0 in.
Lower floor — north.....	56	Kinnear bifold.	16 ft. 1½ ins.	12 ft. 0 in.
Lower floor — south.....	6	Kinnear bifold.	13 ft. 8¾ ins.	12 ft. 0 in.
Lower floor — north.....	4	Kinnear bifold.	13 ft. 8¾ ins.	12 ft. 0 in.
Lower floor — east.....	4	Kinnear bifold.	16 ft. 1½ ins.	12 ft. 0 in.
Lower floor — west.....	4	Kinnear bifold.	16 ft. 1½ ins.	12 ft. 0 in.

Wharf Shed:

Lower floor — south.....	76	Ogden bifold.	18 ft. 0 in.	22 ft. 0 in.
Lower floor — north.....	71	Ogden bifold.	18 ft. 0 in.	16 ft. 0 in.
Lower floor — east.....	3	Ogden bifold.	18 ft. 0 in.	16 ft. 0 in.
Lower floor — west.....	3	Ogden bifold.	18 ft. 0 in.	16 ft. 0 in.
Upper floor — south.....	76	Ogden bifold.	18 ft. 0 in.	16 ft. 0 in.

Pier Sheds:

Lower floor — south wharf	39	Ogden bifold.	18 ft. 0 in.	22 ft. 0 in.
Lower floor — north wharf	39	Ogden bifold.	18 ft. 0 in.	22 ft. 0 in.
Lower floor — east wharf	4	Ogden bifold.	18 ft. 0 in.	22 ft. 0 in.
Lower floor — west wharf	4	Ogden bifold.	18 ft. 0 in.	22 ft. 0 in.
Second floor — south wharf	16	Ogden bifold.	18 ft. 0 in.	12 ft. 0 in.
Second floor — north wharf	16	Ogden bifold.	18 ft. 0 in.	12 ft. 0 in.
Third floor — south wharf	16	Ogden bifold.	18 ft. 0 in.	12 ft. 0 in.
Third floor — north wharf	16	Ogden bifold.	18 ft. 0 in.	12 ft. 0 in.
Lower floor — north track	36	Ogden vertical lift.	18 ft. 0 in.	11 ft. 0 in.
Lower floor — south track	36	Ogden vertical lift.	18 ft. 0 in.	11 ft. 0 in.
Lower floor — north ramp	8	Ogden vertical lift.	10 ft. 0 in.	11 ft. 0 in.
Lower floor — south ramp	8	Ogden vertical lift.	10 ft. 0 in.	11 ft. 0 in.

Allowable Loads. —

Storehouse and Pier Shed.....	500 lbs. per sq. ft. on lower floor.
Storehouse and Pier Shed.....	300 lbs. per sq. ft. on other floors.
Wharf Shed.....	600 lbs. per sq. ft. on lower floor.
Wharf Shed.....	400 lbs. per sq. ft. on upper floor.
Wharf — Pier Shed.....	500 lbs. per sq. ft.
Wharf — elsewhere.....	600 lbs. per sq. ft.

Provisions are also made on the wharves for cranes and heavy locomotives.

Provisions for Master Keys. —

1. A grand master key for every lock in the project.
2. An electric master key which allows passage to any electrical apparatus in any building.
3. A sub-master key for each building, opening every lock in that building.

4. Sub-master keys for special sections of buildings.

5. Individual keys for each lock.

Open Storage Space.—Westerly of Administration Building — 229 000 sq. ft. gross served by 4 200 lin. ft. of standard-gage railroad track in several lines.

Open wharf west of Wharf Shed — 129 600 sq. ft. gross, served by crane track and two standard-gage railroad tracks throughout its length of 1 020 ft.

Open wharf between Wharf Shed and Pier Shed — 39 000 sq. ft. gross, served by two standard-gage railroad tracks throughout its length of 542 ft.

Open wharf between Pier Shed and Boiler House — 2 640 sq. ft. gross, served by one standard-gage track throughout its length of 63 ft.

Wharf. — A continuous wharf with concrete deck surrounds the site. This wharf will provide 4 150 ft. of berthing space on the southerly side; 950 ft. on the northerly side, and 300 ft. on the easterly end, giving a total length of over one mile. The wharf adjoining the Wharf Shed is 35 ft. in width and contains two railroad tracks and one crane rail. The open wharf at the westerly end of the property is 120 ft. in width and contains a double-track railway line and crane rails. The Pier Shed side wharves each have a net width of 28 ft. and provide for one railroad track on north and on south sides of buildings; the wharf at the east end of the Pier Shed is 25 ft. in width.

Berthing Space. — The accommodation for berthing ships is as follows:

Location.	Length of Wharf in Feet.	No. of Ships.	Approx. Length of Ships.*
West of Wharf Shed	1 020	2	300 to 400
Opposite Wharf Shed	1 638	3	400 to 500
Between Wharf Shed and Pier Shed	542	1	400 to 450
Opposite Pier Shed, south side	949	2	350 to 400
Opposite Pier Shed, north side	1 014	2	350 to 400
† At end of Pier Shed	300	1	Small ship.
Total		11	

* The ships under construction by the Emergency Fleet Corporation vary from 380 to 435 ft. in length.

† Emergency use only.

Depth of Channel.—The Reserved Channel on the southerly side of the property, the channel on the northerly side of the property, and the flats easterly of the Pier Shed as far as the main ship channel will be dredged to 30 ft. at M.L.W. Adjoining the Wharf Shed and the Pier Sheds, berthing space having 35 ft. depth is to be provided, thus furnishing opportunity for ships of not more than 32 ft. draft to berth at half tide. Depth of main ship channel from which Reserved Channel leads is 35 ft. at M.L.W.

Disposal of Dredged Material.—Most of the dredged material is rehandled by an hydraulic suction dredge and placed back of a new bulkhead built by the Commonwealth south of the Reserved Channel.

Railroads.—In connection with the plant, a supporting railroad yard with a maximum capacity of 800 cars, exclusive of ladder and running tracks, has been built between Summer Street and the old railroad yard serving Commonwealth Pier. After classification in this yard, cars may be taken to the proper section of the Storehouse by the three tracks on the northerly side of the property, to the Pier Shed by the same tracks or by the two tracks on Terminal Street, to the Wharf Shed by the two tracks on Terminal Street, and directly to the ship side by tracks on the wharves. The tracks in the open space westerly of the Administration Building are for open storage purposes.

Operation.—The Storehouse is to serve as a storage reservoir for freight, thus preventing delays in overseas shipment due to breakdowns in railroad facilities. The Wharf Shed is to be used for the assembling and short-time storage of freight which may be brought in directly either by rail or motor truck, or more commonly from the Storehouse by trailer trucks drawn by electric tractors. It is expected that overseas army supplies will be assembled in the second story of the Wharf Shed shortly before the arrival of a given ship. The ship will then be brought alongside the proper section of the wharf and loaded quickly from the assembled supplies. The Pier Shed is intended for the use of the Navy in equipping ships with supplies, the two upper floors being suitable for storage and the lower floor for transfer or storage.

Elevators.—All elevators are electrically operated. The Storehouse freight elevators are of the automatic, self-leveling type, being equipped with micro-leveling devices, a type of elevator not previously installed in Boston. These elevators level automatically and exactly at any floor. There are twenty-four in all in the Storehouse, four in each section, each of 10 000 lbs. capacity, with platforms 9 ft. 4 ins. by 17 ft. 6 ins. These elevators are of sufficient size to hold four trailer trucks. They may be operated by an operator on the car, but when plant is in full operation the elevators in each section are operated by a dispatcher on the third floor of the section, who will have telephone connections to each floor and to the elevator. The Elevator Supplies Company type of interlocking doors opening automatically when the elevator reaches its proper floor are being installed. Six passenger elevators, each 5 ft. 2 ins. by 7 ft. 0 in. are provided in the Storehouse—one in each section. These elevators have a capacity of 3 000 lbs., a speed of 150 ft. per minute, and are operated by push-button. Five six-ton freight elevators, each 17 ft. 11 ins. by 9 ft. 4 ins., having a speed of 50 ft. per minute with car switch control, are provided in the Wharf Shed. These elevators are furnished with push-button-operated, vertical-lift, double doors of the Peelee type. The Pier Sheds are equipped with 16 six-ton freight elevators, two in each section of each building. These elevators are 19 ft. 2 ins. by 9 ft. 4 ins., have a speed of 50 ft. per minute, and push-button control. They are equipped with double vertical doors of the Peelee type, interlocked with the elevators and operating automatically. The total number of elevators in the project is 51.

Water Supply and Fire Protection.—Water is supplied to the plant by four 16-in. pipe lines, two of which are connected with the Boston low-service and two to the Boston high-service mains, thus providing two practically independent supplies. The pressure in the former system under normal conditions is from 50 to 55 lbs. per sq. in., and in the latter from 90 to 95 lbs. The low-service yard system consists of a single line of 16-in. pipe laid in Dry Dock Avenue, along the north side of the Army Base property. This pipe enters the grounds only at the easterly end near the electric substation. Its function is (a) to fur-

nish supply to three 1 000 g.p.m. underwriter's two-stage centrifugal pumps, and (b) to supply fire hydrants in Dry Dock Avenue for use of city fire engines. It also provides feed water for the boilers. The high-service yard system consists of a loop of 16-in. pipe line surrounding the Storehouse, with 12-in. branch lines extending at the easterly end to supply the Pier Shed. The northerly side of this loop lies in Dry Dock Avenue and the southerly side in Terminal Street. This system supplies water to sprinklers and standpipe in the various buildings, to fire hydrants throughout the grounds, to wharf hydrants for fire protection and ship supply, and for general purposes through the plant.

All buildings used for storage are equipped with sprinklers as described in the following paragraph. The Storehouse and Pier Shed are provided with standpipes in each stairway, with hose and nozzles attached to outlets at each floor. Chemical fire extinguishers and water pails are provided throughout the plant. The Wharf Shed is provided with coils of fire hose with nozzles, supplied from a pipe system independent of the sprinkler system. In the railroad supporting yard, fire protection is furnished for freight cars by means of hydrants placed at intervals on a 16-in. pipe line connected at each end with the city low-service system.

Heating and Sprinkler System.—Heating of the Storehouse is to a considerable extent by hot water which circulates through the sprinkler pipes, the water being heated in heater rooms in each section by live steam brought from Boiler House through tunnel running longitudinally under Storehouse. Auxiliary steam heat is also supplied to wall radiators and to coils at ceiling of upper floor. The Pier Shed is heated entirely by forced hot water, to be brought by pipe line from Boiler House, and has a dry-pipe sprinkler system. Toilets and offices in Wharf Shed are heated by steam, and the building is sprinklered by the dry pipe system. The Administration Building is to be heated by steam. The Boiler House is equipped with six water tube boilers each of 400 h.p. and has room for two additional boilers. Its capacity may be considerably increased if necessary by forced draft, for which fans are installed. Automatic stokers, weighing scales and steam ash conveyors are also provided.

Electricity.—All electricity is supplied by the near-by Edison Company's L Street Plant across the Reserved Channel. Alternating current is delivered at site at 13 800 volts, and is transformed to 2 300 volts at substation for distribution about plant, and again transformed at various points to 110 volts for lighting and 220 volts for power. Direct current from 230 to 250 volts is supplied for use in cranes and dock winches by two 500 kw. rotary converters located in the substation.

Foundations.—The Storehouse foundations consist of concrete cylinders, one under each column, built in open wells formed by sinking concrete shells, 8 ins. thick and 6 ft. in outside diameter, into the hard clay stratum. The wells were belled out at the bottom, to give sufficient bearing area for the column loads, the diameter of the bells at the bottom varying from 11 ft. to 17 ft. 6 ins., depending upon the load to be carried. The open well is filled with concrete and a concrete cap at the top distributes the load over the shell and core. The Wharf Shed foundations are on wooden piles. The interior foundations for the Pier Shed are Raymond concrete piles; the foundations for the exterior columns on the north and south sides respectively of the two buildings are on reinforced concrete sheet pile bulkheads which also restrain the fill.

Freight-Handling Equipment.—The following equipment has been ordered:

Four electric bridge cranes for the Wharf Shed, spanning both tracks on the wharf. These cranes are of the semi-portal type and have booms capable of being both luffed and turned. These cranes have a capacity of $2\frac{1}{2}$ tons at 44 ft. from the face of the wharf, and can be used to transfer freight between hold of vessel and Wharf Shed balcony, the wharf, or cars on the wharf. These cranes use 230-volt direct current.

Two steam locomotive cranes — 15-ton capacity.

One steam locomotive crane — 18-ton capacity.

One steam locomotive crane — 40-ton capacity.

Twenty-four electric dock winches. These are of the portable type and can be used in connection with cargo hoists or to operate ship's gear. Eight of these are provided with remote control apparatus. These winches have a capacity of

2 500 lbs. at 225 ft. per minute. Frequent outlets are provided along the waterfronts of the wharf and pier sheds for plugging in of connections for these winches. They use 230-volt direct current.

Eighty trailers; Seattle type; size 4 ft. by 8 ft.; capacity 5 000 lbs.

Six hundred trailer trucks. These have castor wheels at one end, and are equipped to be coupled in trains and hauled by tractors. They are 3 ft. by 6 ft. in size and have a capacity of 2 000 lbs.

Forty storage battery trailers. Each of these is capable of hauling a train of eight fully loaded trailer trucks of the above size.

Two hundred hand stevedore two-wheel trucks.

Six vertical tiering machines, electrically operated.

Five piling machines for stacking bags.

Six storehouse scales; three-ton; 72 ins. by 60 ins. platform scales with automatic dials.

One 20-ton, platform truck scale.

Estimated Capacity of Freight-Handling Equipment. — Two hundred carloads — 6 000 tons — can be unloaded from freight cars and put into storage in the Storehouse in a ten-hour day.

One hundred forty carloads — 4 200 tons — can be unloaded from freight cars and put into storage in the Pier Shed in a ten-hour day.

One hundred carloads — 3 000 tons — can be unloaded from freight cars and put into storage in lower story of Wharf Shed in a ten-hour day.

An 8 000-ton vessel can be loaded by means of the bridge cranes in about $55\frac{1}{2}$ hours or, say, $2\frac{1}{2}$ days.

Progress. — Permanent construction began on April 22, when the Storehouse foundations were started. The concrete roof of the last section of the Storehouse was poured on October 3. The last concrete of the Pier Shed structure was poured on November 27, and the last concrete of the Wharf Shed structure on December 6. The first goods were stored in the Storehouse on October 25, and consisted of wool. At date of writing, December 6, four floors of Section A are used as temporary

barracks for about 3,000 sailors, the remainder of that section and the whole of Sections B and C being full of wool and miscellaneous supplies. Engineer's schedule called for completion of project on January 1. Slowing down of work since armistice was signed has delayed progress materially by preventing night work and all overtime, and necessitating that concrete work should be done under freezing conditions.

Determination of Site and General Character of Project. — The site was selected by Major-Gen. George W. Goethals, assistant chief of staff, in charge of storage and traffic, U. S. Army, who also determined that the project should be of permanent character and that the main structure should be suitable for commercial use after the war. The storage capacity required and similar features were determined by Col. F. B. Wells, in charge of storage under General Goethals.

Supervision of Construction. — Construction and disbursements of all funds were under the immediate supervision of Major Charles R. Gow, constructing quartermaster, acting for the Construction Division of the Army — Brig.-Gen. R. C. Marshall, Jr., officer in charge; Col. Frank M. Gunby, and Col. Lincoln Bush in charge of engineering; Col. M. J. Whitson and Col. P. Junkersfeld in charge of construction; Col. J. N. Willcutt in charge of materials; Lt.-Col. R. M. White in charge of terminals; Major C. H. Fisk, supervising constructing quartermaster.

Engineering. — Preliminary and final designs, field engineering and inspection, were by Fay, Spofford & Thorndike, Boston, acting as supervising engineers for War Department, with Hollis French and Allen Hubbard acting as associate engineers for heating and power equipment.

Contractors. — The general contractors were the W. F. Kearns Co., of Boston. The subcontractors for construction were P. McGovern & Co. of New York and Boston, for storehouse foundations; Holbrook, Cabot & Rollins Corp., Boston, for wharf construction; Raymond Concrete Pile Co., New York, for pier shed foundations; and T. Stuart & Son Co., Newton, Mass., for railroad track, grading and underground construction. Other principal contractors were the Bay State Dredging and Contracting Co., General Fire Extinguisher Co., Cleghorn Co.,

Edwin C. Lewis, Inc., John C. Finegan Co., and P. W. Donoghue.

Maximum Number Employed on Construction. — The maximum number employed at any one time on the work in Boston, including army officers, engineers, auditing staff, policemen and firemen, was as follows: Army officers, 12; engineers, 259; government auditing staff, 328; policemen and firemen, 106; contractors' forces, 7 125.

Some Approximate Quantities. —

Concrete.....	240 000 cu. yds.
Steel reinforcement.....	13 000 tons
Structural steel.....	4 300 tons
Timber and lumber for forms.....	9 532 000 board ft.
Timber and lumber, miscellaneous.....	7 823 000 board ft.
Timber and lumber, permanent use.....	3 145 000 board ft.
Timber and lumber, total.....	20 500 000 board ft.
Cement.....	445 000 bbls.
Sand.....	123 000 cu. yds.
Stone and gravel.....	216 000 cu. yds.
Dredging.....	3 000 000 cu. yds.
Wood block paving.....	56 000 sq. yds.
Granite block paving.....	28 400 sq. yds.
Granolithic paving.....	197 000 sq. yds.
Bitulithic paving.....	16 600 sq. yds.
Water mains.....	22 800 lin. ft.
Sewers and drains.....	18 000 lin. ft.
Railroad track.....	18 miles
Wooden piles.....	30 000
Raymond concrete piles.....	6 650
Pre-cast sheet piles.....	1 150
Roofing.....	6 000 squares
Brick.....	5 570 000
Metal sash.....	258 000 sq. ft.
Glazing.....	260 300 sq. ft.

Cost. — The engineers' estimate of total cost was \$28 000 000, and this amount was appropriated by Congress. It is now anticipated that the cost will be well within this estimate.

BOSTON SOCIETY OF CIVIL ENGINEERS
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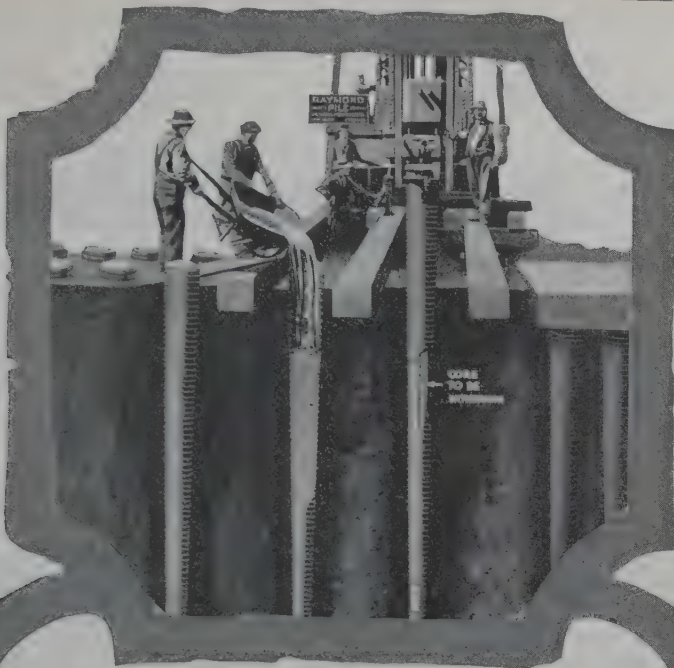
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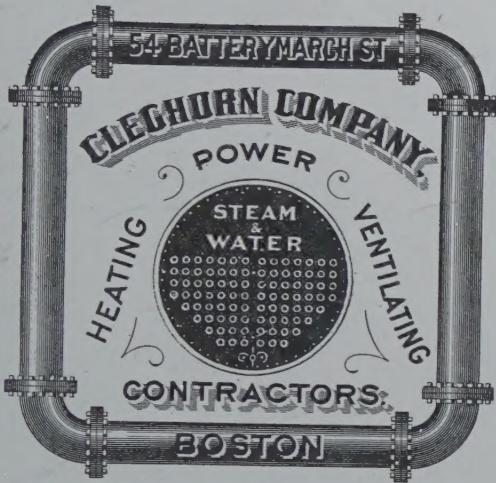
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